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Publications of the Disaster Prevention Research Institute

The Disaster Prevention Research Institute has published the achievements of its research activities in two kinds of publications, namely "Annuals (in Japanese)" and "Bulletins," Bulletins having been monographs published on occasion. Annuals will continue to be published in the same style as before. Bulletin, however, has been changed into a new style with the title of "Bulletin of the Disaster Prevention Research Institute" as seen in this publication.

One Volume of the new Bulletin is divided into four Parts published quarterly, each Part including several articles. Bulletins published in this academic year (April, 1965 ~ March, 1966) constitute Volume 15. Part 4 of each volume includes only the abstracts of papers by staff members of this institute published in a calender year. Corresponding to the new style of publication, Bulletins already published are re-numbered as seen in the end of this publication.

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Aftershocks of the Niigata Earthquake of June 16, 1964.

By Sōji YOSHIKAWA, Tamotsu FURUZAWA and Hiroyasu ONO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 27-34.

Abstract

The aftershocks of the destructive Niigata earthquake (occurring on June 16, 1964, in the Niigata district) were observed using magnetic tape of 3-ch. data recorder from June 6 to June 13 at Nakajo town. During the period 13 aftershocks were observed. The records on analog tape were digitized with A-D converter (DATAC 1030) and punched on the paper tape. The digital records were Fourier-analyzed with the purpose of examining the effects on the spectral structures of P-waves and the main phases due to the different earthquakes and the different ground characteristics. For this purpose, temporary observations were made at two stations, i. e., one on the weathered rock and the other on the alluvium. The Fourier spectra were obtained regarding the P-wave, main phases and the ground noise respectively, using the Kyoto University's KDC-I electronic computer, and each spectrum was compared with regard to the positions and earthquakes.

The main results were as follows:

1. The spectral structure of P-waves depends on the ground characteristics of the station and also differs from each other according to the aftershocks even when the two earthquakes occurred at almost the same position and nearly the same time.

2. The spectrum of the main phase depends largely upon the ground characteristics. The absorption at 2 cps on the alluvium was especially conspicuous. But the predominant frequency of the ground was undetectable.

3. On the alluvium the spectral structure of the main phase of the earthquake is nearly equal to that of the ground noise at frequencies less than 10 cps. But the ground noise on the weathered rock was almost undetectable, though the amplifier gains were the same at the two stations.

On the Seismic Prospecting at the Area Damaged by Niigata Earthquake

By Sōji Yoshikawa, Michiyasu Shima and Noritoshi Gotō

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1964. pp. 11–17.

Abstract

In order to investigate the relations between the ground conditions and earthquake damages, seismic explorations were carried out at the area damaged by Niigata Earthquake on July 16, 1964.

With development of Niigata City, it seems that buildings were obliged to be constructed on the unsettled ground such as a pond, a stream or a paddy-field filled with sand.

Making a tour of inspection of the area, we found that the earthquake damage was closely connected with the elastic properties of comparatively shallow layers of the ground.

In this paper, subsurface structures and some elastic constants of the damaged ground obtained by SH-waves and P-waves are compared with those of the undamaged ground.

SH-waves were generated by striking a wooden plate, being pressed down on the ground surface.

It was clarified that rigidity, poisson's ratio, attenuation coefficient of SH-waves in subsurface layers and ground water level were important parameters of the earthquake-proof of the ground.

On the Exploration by Use of Vibrator at the Damaged Areas by Niigata Earthquake

By Sōji Yoshikawa, Michiyasu Shima and Noritoshi Gotō

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 19–25.

Abstract

In order to investigate the relations between the earthquake damage and the ground condition, explorations of the ground were carried out by measurements of Love type wave at the damaged areas by Niigata Earthquake. That is, the phase velocity of the surface wave of the suitable wave length was adopted as the parameter which may express combined dynamic characteristics of the upper part of the ground. The places investigated are Kawagishicho and Showaohashi (damaged area), and Muramatsuhama-sandhill (undamaged area). The above waves were generated by the vibrator with unbalanced rotating mass, and the vibrator is connected by bolts to the base of an inforced concrete plate which is set on the surface of the ground; the dimension of the base is 170 cm in length, 80 cm in width, 10 cm in thickness.

Love wave was taken out of the surface waves to investigate rigidity of the ground, and for the generation of Love wave, the concrete base was vibrated horizontally in the direction of the length of the base. The vibrator covers the range of vibration frequency from 9 to 15 cps.

The phase velocities (which were measured by those used in usual seismic prospecting) show normal dispersion. The phase velocities at the damaged areas are 100 m/s to 150 m/s and those at the undamaged are 160 m/s to 190 m/s. For the wave length of 10–15 m, the value of the undamaged area is 1.5 to 2.0 times as large as that of the damaged. Therefore, the phase velocity of the Love wave of such a wave length may show synthetically the rigidity of the ground to the depth of ca. 5 m. By use of the data of the thickness and the elastic constants which were obtained in the three areas, the dispersion curves were calculated on the assumption that the ground is composed of two layers. It is found that the subsurface structures obtained by use of Love wave consists reasonable to those obtained by SH wave.

Application of Analog-Digital Converter for Seismic Data

By Sôji Yoshikawa, Tatsuhiko Wada and Tamotsu Furuzawa

Special Contributions, Geophysical Institute, Kyoto University,
No. 4, 1964, 105–110.

Abstract

An analog-digital converter is applied for the analysis of seismic data. This apparatus is generally designed for digitizing the analog data recorded on magnetic tape.

The AD converter used by us is DATAC-1030 (manufactured by Iwasaki Communication Apparatus Co.), of which the main ability is as follows: the range of input voltage is from +9.99 to −9.99 V; the input impedance is over 100 kΩ; the conversion accuracy is ±5 mV+1/2 LSD; the conversion time is 8 μsec; the number of channels is three; the maximum sampling speed is 3,000/sec, when only one channel is used; if an arbitrary oscillator is applied for generating the clock pulse, any sampling speed not beyond 3,000/sec is available.

Digital-analog conversion can also be made, and this process is used for combining any pair of three components to form wave orbital motions. The wave orbits are written on section paper by XY-plotter. In this case, the seismic signals converted in digital form are punched on paper tape by tele-printer and then any pair desired is converted again in analog form. The tele-printer has a maximum speed of 110 characters/sec. If the sampling speed is smaller than that of the tele-printer, the signals are directly punched on the paper tape without recording on magnetic tape.

Some aftershocks of the Niigata Earthquake in June, 1964 were treated with DATAC-1030. The seismic signals recorded on analog magnetic tape were converted in digital form. Then the wave orbital motions of the *p*- and *s*-portions were written in horizontal plane. It is very useful for the determination of epicenter and identifying the phases that the orbital motion is easily obtained by the use of DATAC-1030. Converted data in digital form were used as the input of the digital computer, KDC-I. The Fourier spectrum of the *p*-portion is shown.

Observations of Ultra Microearthquakes in the Vicinity of the Neo Valley Fault in Central Honshu, Japan

By Haruo MIKI, Hikaru WATANABE and Mitsuhiko SHIMADA

ZISIN, Ser. 2, Vol. 15, 1965, pp. 103–112.

Abstract

In August 1963, the observations of ultra microearthquakes were carried out by the Research Group for Ultra Microearthquakes. One of the main purposes of these observations was to elucidate the seismic activity of microearthquakes occurring in Chubu and Kinki Districts, especially in the vicinity of Neo Valley Fault in Central Honshu, Japan. Most of these observations were made by use of velocity seismographs with high magnification (about $10^6 \sim 10^7$mm/kine at short periods less than 1 sec.) in order to register very small earthquakes of seimic magnitudes less than zero and to get a good noise-to-signal ratio at the short period.

During the observation period, about 1,500 earthquakes were observed by our Group at temporary stations, 9 in total, and also at 4 routine stations of Kyoto and Gifu Universities, spread widely over the Kinki and Chubu Districts up to a distance of about 170 km. As the result of the observations, we could find that about 50 earthquakes, including microearthquakes of M less than 2 or 3, were occurring every day in this region. This fact shows that the seismicity of a given region of high activity can be estimated from high-gain recordings during a very short time interval.

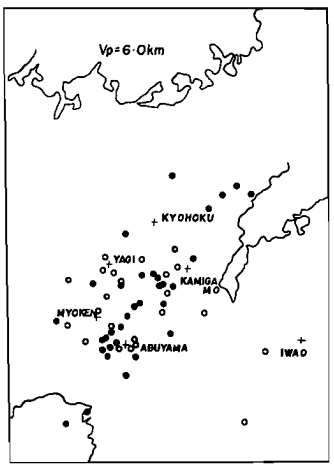
Micro-earthquakes Occurring in the Vicinity of Kyoto

By Kennosuke OKANO and Isamu HIRANO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 117–125.

Abstract

For the purpose of throwing light on the nature of micro-earthquakes occurring in the vicinity of Kyoto, a routine observation was set about in Oct. 1963 at six observation stations newly founded in Kyoto, Osaka and Shiga prefectures.



The six observation stations are shown in the Fig. with their names. The seismographs used at Abuyama, Kyohoku and Iwao stations are of vertical type with a maximum magnification of about 40,000 for a vibration of 0.4 sec. At Abuyama, Yagi and Kamigamo, the stations are equipped with seismographs of horizontal type as well as of vertical type and these seismographs have a maximum magnification of about 20,000 for a vibration of 0.5 sec.

Of micro-earthquakes occurring from the beginning of the observation to June 1963, 100 events were observed simultaneously at more than four stations. The hypocenters of these events were determined by use of the arrival times of P waves under the assumption that the propagation velocity of P waves are constant in the region concerned. The values of velocity were assumed to be 5.0, 5.5 and 6.0 km/sec respectively after the model of the crustal structure of Kinki District proposed by the Research Group for Explosion Seismology.

The epicentral locations of micro-earthquakes are shown in Fig. The micro-earthquakes are, as is known from Fig., very frequent in a belt-like region running from the west coast of Lake Biwa to Osaka Bay with a width of about 25 km. As for the focal depths, most of them lie in the crust.

Furthermore, the magnitudes of the micro-earthquakes treated here were estimated from the consideration of the maximum amplitudes and the characteristics of the instruments. As a result, the magnitudes were found to range from 1 to 3.

Remarkable and fairly remarkable earthquakes were found to be also frequent in the belt-like region mentioned above according to the Seismological Bulletin of the Japan Meteorological Agency. This seismic active belt-like region is geologically characterized by the steep gradient of Bouguer anomaly. The fact that not only micro-earthquakes but larger earthquakes are frequent in this belt-like region might have some relation to the geological features, as deduced from the steep gradient of Bouguer anomaly.

A Simplified Model of Upper Crust from Seismic Wave Velocities at Volcano Aso

By Tatsuhiko WADA and Kosuke KAMO

Special Contributions, Geophysical Institute, Kyoto University,
No. 4, 1964, pp. 91–104.

Abstract

Observation of the volcanic earthquakes occuring near Volcano Aso and the tectonic earthquakes in the vicinity was carried out by the method of a tripartite net using a magnetic tape recorder, and the wireless telemetering system by which seismic signals were transmitted from Hondô, (near the crater), to the Laboratory.

A simplified model of the upper curst of Volcano Aso is deduced from the velocities of seismic waves under the assumption of a homogeneous and parallel layer over half space. Conclusive results are as following:

1. The velocity of P-wave is 2.8 km/sec for the upper layer and 5 km/sec for the under layer from the observation of the tectonic and volcanic earthquakes, respectively.
2. The thickness of the upper layer must be taken as more than 3.7 km to find the velocity of 5 km/sec of the under layer for the assumed structure.
3. The foci concentrate in the limited area near the northwestward rim of the caldera.
4. The depth of focus is deeper on the outside than on the inside of the caldera rim.
5. The initial motions of the volcanic earthquakes except one are push type.

It is interesting that the epicenters at the outside of caldera lie on the line connecting the present active craters of Naka-dake and Kuraga-dake which is an older volcano than the Volcano Aso, and that this line coincides with the main rupture line in the caldera where the four volcanoes, Kisima-dake, Ozyô-dake, Komezuka and Zyano-o lie.

Volcanic Micro Tremor of the Third Kind

By Akira KUBOTERA

Special Contributions, Geophysical Institute, Kyoto University,
No. 4, 1964, pp. 127-139.

Aastract

Nature of the third-kind of volcanic micro tremor at the Volcano Aso and some related problems have been investigated.

At the Volcano Aso, there are four kinds of volcanic micro tremors when classified by their periods, and each has different characteristics. The volcanic micro tremor which has been called "third-kind" by K. Sassa has the Rayleigh type wave form and a period of about 0.5 sec. In the case of the surface wave, in general, its wave forms would greatly be influenced by the conditions of propagation. Therefore, the modes of generation and propagation of the "third-kind" have been determined from its frequency spectrum.

The detailed analyses have been made in a series of simultaneous records of the third-kind volcanic micro tremor taken at two stations by the radio tele-recording system, and it is inferred that this wave is considered to be propagated in the form of the Rayleigh type wave having a phase velocity of about 1.2 km/sec.

The frequency analyses of this tremor have been made using an analog type frequency analyser which has a frequency range of 1 c/s to 43 c/s. From these analyses, it has been made clear that the mode of this tremor has a predominant frequency of about 2 c/s in its frequency spectrum. From the comparison between the spectral form of this tremor and theoretically obtained one of the Rayleigh wave in the layered media, it seems that the third-kind of volcanic micro tremor is the "Airy phase" of the normal mode Rayleigh wave which has been guided in a certain layered medium.

On the other hand, the same predominant frequency which could be considered as the leaking modes in the same layered medium, has also been found on the record of frequency-analysed seismic waves. This phenomenon shows that there is a certain layered medium in which the normal or leaking mode of wave can be guided under the observing station.

The Ishimoto-Iida's "m" value was obtained as 3.44 from the statistical study of the third-kind of volcanic micro tremor when it appeared in the form of isolated wave. This value corresponds to the case of very shallow volcanic earthquakes such as B-type.

The peculiar amplitude variations of this tremor before the small eruption of Nov. 17, 1963 were observed. Such a peculiar variation of volcanic micro tremor has always been observed before eruption of this volcano. Therefore, it may give a clue for the prediction of eruption of this volcano.

Volcanic Micro-tremor of the Volcano ASO (I)
—Nature of the Volcanic Micro-tremor of the Second kind and its Source Condition—

By Akira KUBOTERA

Bulletin of the Volcanological Society of Japan,
Vol. 9, Nos. 2-3, December, 1964, pp. 87-98.

Abstract

The nature of the volcanic micro-tremor of the second kind and its source condition were investigated.

The characteristics of the volcanic micro-tremors at Volcano Aso are closely related to the activity of the volcano. According to K. Sassa, there are four kinds of volcanic micro-tremors when classified from their periods, and these tremors have different characteristics.

The volcanic micro-tremor of the "2nd kind" is a long period of 3.5 to 7.0 sec. The period of this tremor is maintained for the duration of unchanged activity of the volcano. The mode of this tremor corresponds to the compressional one and was observed in the form of several groups of regular wave trains during inactive periods, while during active periods it became a continuous train of somewhat irregular waves.

The wave forms of this tremor on the seismograms depend on, in general, the characteristics of the active origin of the volcano, the mode in which waves have propagated and observed instruments.

The spectrum of waves having a long period and compressional wave forms such as the 2 nd kind may be taken to indicate information concerning the non-distorted source conditions. For this reason, an attempt was made to determine the source conditions of the 2 nd kind of volcanic micro-tremor from its frequency spectrum.

Fourier spectral analyses of the ground motion due to the volcanic micro-tremor of the 2 nd kind have been made by using several selected seismograms. This spectrum is consistent with the predicted spectrum of the damped oscillation system generated by the impulsive exciting force. The predicted oscillation system with damping factor $h=0.1$ to 0.07 shows nearly free oscillation and may be regarded as non-distorted information of the source condition of this tremor.

From the investigation of K. Sassa, the volcanic micro-tremor of the 2 nd kind is understood to be guided waves because of the free oscillation of magmatic chamber beneath the active crater and the instigation of chamber vibration due to explosions of gas involved.

The oscillation of a magmatic chamber as the source of this tremor is substituted approximately for the model of the oscillation of a liquid sphere. Numerical computations have been made by using this model which is proper in the volcanic region.

From the comparison between computed results and the predicted oscillation system, it is found that the density of the inner part of the magmatic chamber may be of the same order or somewhat smaller than the outer part, and the

chamber radius is estimated to be about 2–4 km from the interpretation of the period of this tremor.

The predicted oscillation system from the computed results is in good agreement with the observed results. Therefore, it is concluded that the volcanic micro-tremor of the 2 nd kind originates from the free oscillation of a magmatic chamber as has been predicted by K. Sassa.

Crustal Structure in Central California in Relation to the Sierra Nevada

By Takeshi MIKUMO

Bulletin of the Seismological Society of America,
Vol. 55, No. 1, 1965, pp. 65–83.

Abstract

Crustal structure in central California (between the latitudes of 36° and 41°N) including the high mountain region of the Sierra Nevada has been studied by a combined analysis of travel times of Pn waves, dispersion of surface waves, and correlation between computed and Bouguer gravity anomalies.

It has been found, in the observations at recording stations distributed along the Pacific coastal region, that there is a strong azimuthal dependence in travel times of Pn waves from Nevada explosions and earthquakes. In order to explain this phenomena and the Bouguer anomaly down to as low as −180 mgals, simple two-dimensional models were presented for the structure, which is, as a first approximation, like a horizontally truncated wedge with the thickest portion of the crust beneath the Sierra. The parameters specifying the crustal models were determined from the Pn observations by least squares using a successive iteration and convergence technique. Theoretical gravity anomaly distribution expected from the derived models was then computed by a two-dimensional method and compared with Bouguer anomalies.

In the preferred model, in which the computed anomalies agree well with the observed values, the average compressional velocities in the crust and mantle are 6.30 and 7.95 km/sec. With these velocities, the overall crustal depths to the Moho-discontinuity are found to be about 22 km beneath the Pacific coastal area, 26 km for the Central Valley, and 43 km in the Sierra Nevada, indicating a steep crustal thickening under this high mountain region.

The dispersion of group velocities of Rayleigh and Love waves passing through the region from Nevada and Utah earthquakes was also investigated at both sides of the Sierra. The observation of Love waves from the Utah earthquake gave support to the preferred model, with a fairly good agreement to the computed group velocities.

Determination of Phase Velocity and Direction of Wave Approach from Station Arrays

By Takeshi MIMUMO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 1, 1965, pp. 31–43.

Abstract

The multipartite station array method is described in comparison with the conventional tripartite technique, to determine the local phase velocity and direction of wave approach of seismic waves. The latter technique has been widely used for both body and surface waves to measure the two parameters of the waves, but this is not always applicable to detailed studies of crustal structure, epicenter determination and of some other related problems, since the probable errors cannot be estimated, and this situation could introduce some distortion in the results due to local structural irregularities.

The array technique is generalized to the case of multipartite stations distributed over a limited area. The apparent wave velocity and direction of approach averaged over the area, with their probable errors, can be determined from arrival times of coherent waves observed at the stations, by means of linear least squares taking the center of gravity of the array as a reference point. Both of the two methods have been applied to teleseisms recorded at the Berkeley network, California and to near earthquakes observed at the Wakayama network, western Japan. The results show that the multipartite least squares gave the averages which in most cases agree within the probable errors with their expected values, while selected sets of tripartite net yielded a mean variation of 20% in the velocity and 9 degrees in the direction. There was some significant deviation in the computed results from the expected values for the observation made at Berkeley, which might be attributed to variations in crustal structure under the Pacific coastal region.

On the Accuracy of Tripartite Method

By Michio HASHIZUME, Kazuo OIKE and Yoshimichi KISHIMOTO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 1, 1965, pp. 7-29.

Abstract

A cooperative observation of microearthquakes was made in the northern part of the Neo Valley Fault in 1964, by ten parties of universities and institutes in Japan. One of the purposes of this observation was to re-examine various methods for determining the hypocenter, those being three methods by the use of arrival time of P wave, P-S time and the so-called tripartite method. The tripartite observation was carried out at six stations.

18 earthquakes, including one intermediate deep one, in which the tripartite observation was successful, at least, at two stations, were analysed as to P wave for the purpose of examining the accuracy of tripartite method. The results are as follows;

(a) Case in which 4 stations were available.
1. Hypocenter was determined well: 0
2. Hypocenter was determined if one station was omitted: 4
3. Epicenter was determined, but focal depth was not: 1

(b) Case in which 3 stations were available.
1. Hypocenter was determined well: 4
2. Epicenter was detemined, but focal depth was not: 2
3. Both epicenter and focal depth were not determined: 3

(c) Case in which 2 stations were available.
1. Hypocenter was determined well: 4
2. Epicenter was determined, but focal depth was not: 3

These results suggest that the determination of epicenter by the tripartite method is considerably reliable, if we take the observational error into consideration, but as for focal depth some problems are left. Deviation of both approaching direction and apparent velocity may be caused by the irregularity of superficial and underground structure.

On the M_1-Component Obtained by Gravimetric Tidal Observation (Screening of Gravitational Forces)

By Ichiro NAKAGAWA

Special Contributions, Geophysical Institute, Kyoto University,
No. 4, 1964, pp. 9–17.

Abstract

Absorption of gravitational forces has mainly been investigated during periods of solar eclipse by several investigators, and it has been established that the absorption effect of gravitation, if it exists, does not exceed the noise level.

The mass of the earth is larger than that of the moon and therefore the gravitational absorption due to the earth's mass itself should be larger than that due to the moon's mass.

In the present paper, a trial to detect the absorption effect of the lunar gravitational forces by the earth's mass is described by using data obtained with an Askania gravimeter No. 111, installed at Kyoto, during a period of one year. By the present investigation, it is ascertained that the gravitational absorption due to the earth's mass is about 4 μgal and that its value reaches a maximum of two hours after the instant when the moon transited the meridian of the observation station. The value of amplitude obtained by observation is in good agreement with that predicted by theoretical calculation. But concerning the phase, there exists a difference of about 180° compared with that expected by theoretical calculation.

Characteristic Movements of the Earth's Crust related with the Activity of Earthquakes

By Tokio ICHINOHE and Yutaka TANAKA

Journal of the Geodetic Society of Japan,
Vol. 10, Nos. 3-4, March, 1965, pp. 154-162.

Abstract

Since 1937 continuous observation on the crustal movement with tiltmeters and extensometers has been carried out by members of Kyoto University at twenty observing stations in Japan. In these observing stations fifty-two tiltmeters and thirteen extensometers are in operation at present. For about twenty-eight years from 1937 to the present day there has occurred scores of remarkable earthquakes and innumerable moderate and small earthquakes in Japan. Some of these remarkable earthquakes were accompanied with characteristic crustal movements before and after the occurrence of earthquakes.

From the analysis of the observational data, it proved that characteristic crustal movements were clearly observed just in the direction in which the horizontal displacement of the crust was prominent, relating to the activity of earthquakes. Comparing it with the data obtained by geodetic and seismometric observations, it was naturally inferred that almost all the shallow earthquakes should have been caused by some force closely related with the tectonic force generating the horizontal displacement of the crust in that region. And further, in the case of the observing station being situated near the epicenter, the crustal movements proceeded generally through three stages. This fact offers valuable information for study on earthquake prediction.

On the Stages of Anomalous Crustal Movements accompanied by Earthquake

By Yutaka TANAKA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 7, 1964, pp. 39–49.

Abstract

In the direction of the horizontal displacements of the triangulation points, tilt variations always show the most remarkable mode, as the crust behaves over a wide area the see-saw motion decreasing amplitude and period with time, accompanying earthquakes at its peakes.

The first stage of anomalous crustal movements before earthquake corresponds to this mode, so it appears characteristically in the direction of the horizontal displacement, in an other expression, it may be also the direction related to the tectonic force. The second stage is the movements of the strain concentration, so the ground tilts toward or opposite to the epicenter, relating to the earthquake mechanism. The third stage just before earthquake is the process of rapid increase of creep or beginning of fracture, perhaps foreshock-occurrence, so that the tilt variations increase their own rate in the same motion as the second stage near the epicenter, or reverse their direction at a far distance from the epicenter according to the beginning of energy release. After the earthquake these anomalous movements continue until the termination of the aftershock activities.

These stages and phenomena appear remarkably in the case of shallow earthquakes, and a little differently in the case of intermediate earthquakes.

Relation between Crustal and Subcrustal Earthquakes inferred from the Mode of Crustal Movements

By Yutaka TANAKA

Special Contributions, Geophysical Institute, Kyoto University,
No. 4, 1964, pp. 19–28.

Abstract

The crustal movement connected with subcrustal earthquakes must be interpreted as the following. Namely, it is not directly connected with and does not correspond to individual subcrustal earthquakes, of courese, it is also not caused by them. But it is only a reflection (over a wide area because of depth) of change in movement of material as plastic flow and deformation under high pressure and high temperature or in state of strain-accumulation and -release within the mantle. Subcrustal earthquake occurs merely at the peak of the change, so that the amount of crustal deformation is not related to the magnitude and epicentral distance of individual earthquake. The changes in states of slow movement or of strain energy in the mantle, however, must have a great influence on the crust over a wide area and it is enough to give an impetus to the brittle crust and to cause a series of crustal earthquakes. When the conditions of impetus are changed according to the generation of subcrustal earthquake, the state in the crust and variation rate of secular ground-tilt are also changed, in this manner alternation of crustal earthquake sequence may be carried out.

Besides, the relation between the time variation of earth tidal amplitude observed at Makimine and seismic activity in the Hyûganada, investigated by the late Professor Eiichi Nishimura who had always taken a great interest in this problem, in other words, change in elasticity of the crust as he supposed, may be closely connected with alternations of earthquake sequence and change of mean velocity of secular tilt variation.

On the Ground Deformation and the Phenomena Forerunning the Natural Disasters (Earthquake, Rock-falling and Landslide)

By Michio TAKADA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, March, 1965, pp. 1–26.

Abstract

Using the extensometers and tiltmeters, the observation of crustal deformation in the underground galleries at Ide Observatory and others, and the observation of ground deformation on the ground surface at Kamenose Landslide Zone and others, have been carried on from old times. Before the occurrence of an earthquake, rock-falling or landslide, some peculiar changes of ground-strain and ground-tilt which may be regarded as these forerunning phenomena were observed.

On July 18, 1952, the strong Yoshino Earthquake occurred in the southern part of Nara Prefecture. In this case, the peculiar changes several months before the earthquake-occurrence were observed at Ide Observatory. The ground-strain gradually became large since about March and it increased after the middle of June. Soon after, on July 13, just 5 days before the earthquake-occurrence, the direction of variation turned. The similar variation of ground-strain was observed by Prof. I. Ozawa at Ōsakayama Observatory. And the ground at Ide continued a downward tilting in an S-direction since about March. But, on July 5 just 13 days before the earthquake-occurrence, its tilting direction turned in the contrary direction. Such changes of tilting direction were detected at Ōsakayama Observatory and Yura Observatory (after Prof. I. Ozawa and Dr. K. Hosoyama), i. e. the ground-tilting direction turned on July 8 at Ōsakayama and on July 2 at Yura. These changes of ground-strain and ground-tilt several days before the earthquake-occurrence are similar to those variations obtained elastico-dynamically from the earthquake mechanism of the Yoshino Earthquake. It is thought that the ground in the neighbourhood of the hypocentre begins to deform similarly to the deformation at the occasion of earthquake which will occur in several days.

On Dec. 24, 1954, a part of drift was broken and the rock-falling occurred at the Ide Observatory. The peculiar changes of ground-strain and -tilt were found from about Dec. 7 before the rock-falling occurred.

At the end of 1963, a small-scale landslide due to soil mass removal occurred at Kamenose Landslide Zone. The ground surface was gradually deformed from about Dec. 7 and it was broken on the 17 th making cracks. In this case, from the results of the observations by extensometers and tiltmeters, peculiar variations were found which seemed to be the forerunning phenomena to the landslide.

Like the earthquake, rock-falling and landslide, in the case of phenomena caused by destruction of rocks and land blocks, the energy for destruction is accumulated gradually. After that, the great destruction occurs and its energy is released. Accordingly, the ground deformation occurs with this action. It is believed that if observations of the peculiar variations in ground-strain and ground-tilt are carefully kept, the forerunning phenomena can be detected and a clue is found to the prediction of earthquakes, rock-fallings and landslides.

Some Natures of Volcanic Earthquake at Sakurajima-Volcano

By Keizo YOSHIKAWA, Tatsuhiko WADA,
Kosuke KAMO and Hiroyasu ONO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 35–42.

Abstract

Observations on volcanic earthquakes with three components of seismographs and two small tripartite nets were carried out in August, 1962 and in July, 1963 at Sakurajima Volcano.

Examining the wave-orbits and analyzing the apparent velocities and the directions of the approach of waves, we obtained the results as follows: (1) The nature of origin of the observed earthquake is an explosive one, since the clear S-phase, which is to be found in tectonic seismic waves, cannot be observed. (2) The origins of the earthquakes are located beneath the summit crater (Minami-dake). (3) The seismic waves are divided in two groups, the first group consists of P-waves having the apparent velocity ca. 2 km/sec. and the second group consists of surface waves having their phase velocity ca. 1 km/sec. (4) The approaching directions of P-waves disagree with those of the surface waves. It seems this is not only due to the crustal structure but is related with the depth of earthquake origin. (5) In spite of the lack of SH-motion, the surface waves of Love-type are found similarly to the underground nuclear explosion.

Seismic Observation at the Volcano Sakurajima (3)
(On the earthquake swarm just before the eruption)

By Keizo YOSHIKAWA and Kiyoshi NISHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 43–50.

Abstract

To study the prediction of volcanic eruption, seismic routine observation with high sensitive seismographs has been carried out since 1962 at Sakurajima Observatory, Kyoto University. On the seismograms of this observation, we sometimes found a tremendous earthquake swarm in the case of an eruption. The frequency of these earthquakes became greater and greater with time, and at last they appeared in continuous tremores just before the eruption. Otherwise, the maximum amplitude of them became larger and larger till the eruption. After eruption, the frequency and maximum amplitude both became smaller and smaller as time went on. It seems that all of these earthquakes have their origin quite near the crater.

Owing to our finding such a tremendous earthquake swarm, we have been able to surely predict some eruptions, which accompanied detonation and threw out ejecta.

Seismic Observation at the Volcano Sakurajima (4)
(On the classification of volcanic micro-earthquakes and frequency distribution of each types)

By Keizo YOSHIKAWA and Kiyoshi NISHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 51–58.

Abstract

Micro-earthquakes appearing to have their origins near the crater of Sakurajima are classified into 4 types by their dominant period or their duration of vibration.

SP type is one whose dominant period is about 0.1 sec. or less, BS type about 0.2 sec. and B type about 0.3 sec. which is observed very frequently. D type has a long duration of vibration, which is accompanied with gas emission.

Examining the relation between the frequency distributions of each type and the eruption in the active stage from the latter part of Oct. to the begining of Nov. in 1963, the following relations are found.

SP type goes on increasing its frequency to a peak and after then decreases.

The number of BS type suddenly increased in the two or three days before the explosion, and decreased in the time of eruption.

B type is common in all stages, and D type increase to some extent after a violent explosion.

A Recording Water Tube Tiltmeter

By Tsuneo ETO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 59-69.

Abstract

Water tube type tiltmeters which measure the respective elevations of points of the earth's surface are indispensable for the measurement of secular tilting movements of the earth's crust. In this paper, the writer began to develop the recording water tube tiltmeter with a long distance between two water reservoirs installed at a certain depth under the ground.

In order to record continuous informations on volcanic crustal deformations in the vicinity of Volcano Sakura-jima, one component recording water tube tiltmeter was installed in the underground tunnel at the Hiyamizu observation station which belongs to the Sakura-jima Volcanologicl Observatory.

A hardend vinyl chloride tube with an inside diameter of 16 mm and 45 meters in length serves as the water tube. On both side of the water tube, a compensating reservoir and a recording pot are attached. The compensating reservoir is a stainless steel tub of 50 cm diameter. On the other hand, the recording pot is a glass pot which is 12 cm in diameter.

The recoding methods of the change of level in the water surfaces of the apparatus contain two groups: instruments with visual point readings by micrometers, and instruments with continuous recordings by the optical method.

It is possible to control the sensitivity of the water tube tiltmeter on the recording photographic paper by changing the optical magnifications in various methods. The sensitivity of the recording water tube tiltmeter at the Hiyamizu station can be changed to 0.0069 second/mm, 0.011 second/mm and 0.013 second/mm by the diameter of the pulley. Good results have been obtained when this water tube tiltmeter was set in an underground tunnel where the effects of the atmospheric pressure gradient and the temperature change were few.

Volcanic Crustal Deformations (I)

Relations between the Recent Vertical Deformations and Volcanic Activities at Volcano Sakura-jima

By Tsuneo ETO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 71–82.

Abstract

The vertical deformations of the earth's crust in the vicinity of Volcano Sakura-jima accompanied with the recent volcanic activity are studied from the results of precise levelling surveys.

The vertical displacements of the ground surface at Volcano Sakura-jima were roughly explained as the elastic deformations which are caused by the increase or decrease of hydrostatic pressure of two spherical internal pressure sources or magma reservoirs. Those pressure sources were supposed to exist under the center of Aira Caldera and under the center of Volcano Sakura-jima. Contours of change in elevation between the time of the two successive surveys show the character of those crustal deformations.

As useful parameters of volcanic activity, the yearly number of explosions at Minami-dake crater and the yearly total sum of the square of maximum amplitude of explosion-earthquakes recoded by S–50 seismograph at the Higashi-sakurajima station, were compared with the elevation change of B. M. 29 and B. M. 111. There were fairly close correlations between the elevation change and the recent volcanic activity at Volcano Sakura-jima.

The Restoring Force Characteristics of Multi-Storey Frames

By Minoru WAKABAYASHI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 2, No. 78, Feb., 1965, pp. 29–47.

Abstract

The object of this paper is twofold. One is to clarify how vertical loads affect the restoring force characteristics of rigid frames when subjected to horizontal loads. The other is to examine the behavior of frames under repeated horizontal loading.

For the response analysis of frames due to earthquake excitation, the horizontal load-displacement relation should be established. Existence of vertical loads tends to induce some instability on the restoring force characteristics. First, the elastic stabilty of multi-storey multi-bay frames is discussed. The effective buckling lengths of columns in those frames are illustrated for vertical loads only. Then, a practical method of analysis is presented for elastic multi-story frames subjected to vertical and horizontal loads. An experimental study is made of the restoring force characteristics of elastic-plastic rectangular portal frames under constant vertical loads and varying horizontal load using mild steel miniature models. It is shown that the restoring force is reduced by a considerable amount due to large veritcal loads, indicating that the weakening effect should not be disregarded in lower stories of a multi-storey frame.

Some tests are carried out on portal frames with and without bracings subject to a repeated horizontal load. It is shown that diagonal bracings increase the energy-absorption capacity appreciably and that they contribute to allowing large deformation without failure. It is concluded that adequately arranged bracings in multi- storey frames are very effective as aseismatic structural elements.

Study of Elasto-Plastic Stability of Steel Portal Frames Subjected to Vertical and Horizontal Loads

By Minoru WAKABAYASHI and Chiaki MATSUI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 127–139.

Abstract

Experimental studies are made of the effects of vertical loads on the behavior of rectangular steel portal frames subjected to horizontal loads. The situation is supposedly encountered in lower storeys of a tall frame under earthquake motion.

A specimen is composed of two similarly made miniature rigid portal frames, both being connected to each other in order to prevent lateral buckling of the frame. A frame is cut out by a machine, without heating, from a mild steel plate stock with 10 mm thickness. The span and column height are chosen to be 200 mm. The elastic flexural rigidity of the beam is either equal to or half that of the columns. 100, 50 and 30 are adopted as the ratios of the column height to its radius of gyration. Constant vertical loads are applied by oil jacks at the tops of the columns symmetrically; the loads sre 0%, 10%, 20% and 40% of the elastic or the tangent modulus buckling load of a frame due to vertical loads only. A varying horizontal load is applied slowly by a testing machine to one direction of the beam axis. The side displacements are measured by means of a dial guage.

It is observed that the restoring force characteristics, or the shape of the horizontal load-displacement curve, greatly depends on the magnitude of the vertical loads. The slope of the curve decreases as the horizontal load increases; when the vertical loads are large the slope becomes negative after a certain displacement is reached. As the vertical loads increase, the maximum horizontal load decreases and the stability limit displacement also decreases. When the vertical loads are small, the maximum horizontal load is fairly well predicted by the analysis based on the assumption that the behavior is elastic until full plastic state is reached at a section. When the axial forces are large, however, the assumption gives too large a prediction for the maximum horizontal load.

The Behavior of Frames Under Repeated Horizontal Loading

By Minoru WAKABAYASHI and Bunzo TSUJI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 141–151

Abstract

To investigate the elastic plastic characteristics of a rigid steel frame under horizontal loading some experiments were made with miniature portal frames of mild steel. A specimen was composed of two identical frames both being cut from 12 mm-thick plate stock and connected to each other at the joints to avoid lateral buckling. The ratios of the bending stiffness of the beam to column are 0.944 and 1.000 each with and without bracings. Horizontal loads are applied at the top of the columns either monotonously or repeatedly. For frames with strong beams loads are applied in such a way that no axial forces are induced in the columns. The horizontal deflection and stress distribution are measured by means of dial gauges and wire strain gauges.

The load-deflection curves for the frames without bracing indicate that the simple elastic bending theory overestimates the initial rigidity. The measured maximum load is observed to be 10 to 20% larger than that estemated by simple plastic theory. It is found from the experimented load-deflection curve for repeated loading that in the case of frames without bracings the slope of the curve in the unloading process is not far from the initial slope even under large deflection amplitude. For frames with diagonal bracings the initial slope is large as compared with frames without bracing, but after buckling of the compression bracing horizontal deflection increases rapidly and unstable equilibrium state is reached under a large deflection. The slope of the curve in the unloading process is small for large deflection amplitude. The relation between the deflection amplitude and the equivalent viscous damping ratio indicates that the diagonal bracings contribute in the absorption of energy even under small deflection.

On the Buckling Strength of Angles in Transmission Towers

By Minoru WAKABAYASHI and Taijiro NONAKA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 2, No. 91, Nov., 1965, pp. 1–18.

Abstract

It is assertained that buckling or instability of angles has been the main cause of destruction of the super-structure of steel transmission towers due to typhoons.

Experimental studies are made of the buckling strength of angles, using mild steel with a L−90 mm×90 mm×7 mm profile. A total of fifty-seven specimens are tested. Various eccentricities and slenderness-ratios are included. Behavior and modes of buckling failure are observed. Bending, torsion or Beulung (local bucking of plate elements) plays an important role in the buckling phenomena of angles, according to eccentricity and angle dimensions. A general agreement is seen between the experiment and buckling theories. It is shown both experimentally and theoretically that the carrying capacity is reduced considerably by eccentricities of the order of the radii of gyration. There is some difference in the effects of eccentricities on the symmetric axis and on the asymmetric principal axis of the cross-section. The eccentricity on the symmetric axis reduces the capacity for all the lengths of interest. This is concerned with bending deformation; bending largely occurs due to the eccentricity before the maximum load is reached, because of small flexural rigity for bending in the plane of symmetry. The decrease in the capacity due to the eccentricity on the asymmetric principal axis is, on the other hand, not appreciable for long angles (for eccentricity of the amount given here). The decrease for short angles is primarily caused by local buckling or torsional deformation, but the carrying capacity of long angles is mainly concerned with bending in the most flexible direction, i. e., in the symmetric plane.

Carrying capacity is considered for compressed angle members in actual steel transmission towers, based on the experimental and theoretical results. As an approach to the safe and economical design of towers, safety factors of the JEC (Japan Electric Code) allowable buckling stresses are examined, and revision of the code is proposed such that an upper-limit of the slenderness ratio of compressed angles should be specified for post members and the allowable buckling stress should be lowered for short web members.

Studies on the Explosion (Part 1): on the Prilled Ammounium Nitrate

By Yoshikazu WAKAZONO and Shigetaka KITAO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 153-164.

Abstract

Observing prilled ammonium nitrate by the electron and optical microscopes, we recognized that a pill of granular porous ammonium nitrate consisted of smaller particles, which are called the "primary particles", and that the granular porous prilled ammonium nitrate pill formed the "secondary particle" by itself. We also measured its bulk density, ratio of oil absorption, and the detonation velocity of ammonium nitrate (AN) fuel oil (FO) blasting agents, i. e. the mixture of the prilled AN and FO. We further made the cap sensitivity tests and the drop hammer tests.

Through these measurings and testings, it could be contemplated that the exploding or detonating properties of AN-FO were influenced by the reaction of AN upon FO, which was caused on the boundary between the solid (AN) phase and liquid (FO) phase, and we concluded that the prilled AN which had the following properties was the most suitable for ANFO blasting agents; bulk density: 0.75~0.85 g/cc, ratio of oil absorption: 10~20 g/100 g AN, water content: 0.5% or below, detonation velocity: 2,500~3,300 m/s, cap sensitivity: unable to be detonated by a No. 8 cap.

Studies on the Explosion (Part 2): on the ANFO Blasting (1)

By Yoshikazu WAKAZONO, Chugoro SATO and Sadao UMEDA

Annuals, Disaster Prevention Reserch Institute, Kyoto University,
No. 8, March, 1965, pp. 165–170.

Abstract

We tried the practical blasting by the bench cut method at the dam site, consisting of quartz trachyte, at Kasabori, Niigata Prefecture, Japan, using the the ANFO blasting agents of the prilled AN which had the following properties; bulk density: 0.7~0.8 g/cc, ratio of oil absorption: 11~17 g/100 g AN, water content: 0.5% or below. We used approximately 15 kg of the ANFO blasting agents for each bore hole. We took the photographs of the test blasting by high speed camera in order to observe the aspects of the blasting.

Through the practical blasting, and observing by photographs, we came to the conclusion that the ANFO blasting agents were inferior to ammonium perchlorate explosives in view of the blasting force, and that the ANFO blasting agents were effective only when used in the dry holes. Also, we discussed the priming methods, and recognized that the percentage of the booster, per total weight of ANFO, needed to be 1% or more, for effective blasting by ANFO, when the diameter of the bore hole was more than 3 inches.

Studies on the Explosion (Part 3): on the Propagation of Detonation in Prilled An

By Yoshikazu WAKAZONO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 171–176.

Abstract

The propagation of detonation of prilled ammonium nitrate has not been sufficiently clarified in spite of many reports on ANFO.

In order to clarify this problem, the writer investigated how booster and loading conditions had an influence on the detonation velocity of ammonium nitrate fuel oil blasting agents (ANFO).

The writer measured the detonation velocity of ANFO, by the Dautriche method, and discussed the influence of booster and hole diameter on the detonation velocity, influence of weight of booster and hole diameter on the detonation velocity, and influence of hole diameter and loading density on the detonation velocity.

The results obtained are as follows:

(1) The detonation velocity of ANFO depends upon both kinds and quantities of booster. If the booster having higher detonation velocity is used, or if the proportion of booster to ANFO is increased, higher detonation velocity of ANFO is attained.

(2) As the hole diameter or loading density increases, detonation velocity of ANFO increases. But when other expolsives are used, even if the diameter or loading density is increased, the detonation velocity does not increase so much as ANFO.

Report on the Industrial Disaster by Earthquake at Niigata

By Yoshikazu WAKAZONO and Naojiro ANDO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 177–191.

Abstract

The earthquake which occured at 1 : 10 p. m. on the 16th of june 1964 caused various disasters all over Niigata Prefecture. In this report we discussed industrial disasters, mainly those of fire and air pollution due to the burning of petroleum at Showa Oil Company's Niigata Refinery, plus damage caused by the petroleum flowing from Nihon Oil Company's Niigata Refinery. Other characteristics of industrial disasters following the earthquake, were as follows.

(1) There was no outbreak of fire from residential quarters at all.
(2) There were few casualties.
(3) Fire caused by oil leakage broke out.
(4) Conflagration occurred at petroleum plants.
(5) Inflammable materials flowed, and were spread by tidal wave, from the overflowing of the river.
(6) Oil contamination and air pollution was concentrated around petroleum refineries.

We observed these characteristics and discussed the means to prevent the spread of industrial disasters, caused by earthquare especially in chemical factories.

From these observations and discussions, we came to the conclusion that the following three fundamental principles are important for preventing industrial disasters from spreading.

(1) To arrest disasters at their beginning.
(2) To limit the extent of disasters.
(3) To prevent disasters from spreading.

Studies on Explosion. I

By Yoshikazu WAKAZONO and Shigetake KITAO

Bulletin of the Disaster Prevention Reseach Institute, Kyoto University,
Vol. 15, Part 3, March, 1965.

Abstract

The exploding or detonating properties of ammonium nitrate (AN) have been recognized for many years. Also, it has been generally known that the exploding force of AN increases when AN includes some carbon sources.

On account of its exploding properties, AN has been utilized as material for the coal mining ammonium nitrate explosives and as a blasting agent with carbon black of aluminium powder. Of late, ammonium nitrate fuel oil mixtures (ANFO) have been used for blasting in many countries, especially in U. S. A. and Canada.

Studies on the exploding properties of AN FO have been in progress for some years. At present, it is important to understand these studies for more effective use in blasting, or new utilization of ANFO. It is also significant to study them in view of the reactions which propagate on the boundary between solid (AN) phase and liquid (FO) phase. In this report we consider the properties of ANFO by observing several kinds of AN with the electron and optical microscopes, by measuring detonation velocity and by carrying out sensitivity tests.

Through these measurings and testings, we concluded that the detonation velocity, and exploding force together with the sensitivity of ANFO were subject to the marked influence of the bulk density, oil absorption, particle size, coating agents, and water content of ammonium nitrate as well as methods of initiation, loading length, diameter and density of ANFO.

Results of A Static Loading Test on A Steel Model of Kyoto Tower

By Ryo TANABASHI, Kiyoshi KANETA and Kazuo SUZUKI

Transactions of the Architectural Institute of Japan, Special Volume, September 1965, pp. 330.

Abstract

The structure of Kyoto Tower is certainly different from other steel towers. The top half of the tower is a cylindrical steel shell like steel stacks while the bottom is assembled into a complicated frame work with eight inclined columns and beams to ring around the columns at four different elevations.

Difficulties of design stress calculation was observed at the bottom part of the structure when lateral loads of earthquake and wind were applied. The space structure would withstand the loads relying upon the flexural and torsional rigidities of beams and columns. However, since the lateral load carrying capacity for each column was unknown, the design of the frame was made on a very conservative basis of discarding the torsional rigidities of the members.

In order to clarify the load carrying capacity of columns, the stress distribution in members and configuration of the frame under the specified base shear, an experiment was attempted on a 1/15 scale steel model resembling the shape and loading conditions of the prototype. Similitude of the variation in the thickness of the steel plate for members and of the joints between the model and the prototype were not attained.

The results of the test carried out under the static loading have shown us a good coincidence of the stress distribution to that measured at the test and that had been assumed at the design. It was estimated from the results that under the design loads the maximum stress developed in the model the stress in the prototype would be of the order of a quarter of the yield point stress of the material used. Also, the load carrying capacity for each column was estimated, and the result was regarded as useful for structures of this type which will be constructed in the future.

A Preliminary Experiment on the Strength of Welded Joints of Steel Frames under Two-axial Stresses

By Ryo TANABASHI, Kiyoshi KANETA and Etsuo TSUDA

Technical Reports of the Architectural Institute of Japan, Kinki Branch, May 1965, pp. 57–60.

Abstract

A preliminary experiment was carried out on the breaking strength of fillet weld joints. Three pieces of high tensile steel plates were welded to make a cross-type test specimen. The material was Yawata Iron and Steel Manufacturing

Company, Incorporated's Y. E. S. 36—a semi-killed steel with heat treatment.

The fillet weld joints were loaded by using a jig and an Amsler-type testing machine so as to develop a two-axial stress, namely, a compressive stress, whose magnitude was kept constant, in one direction and a tensile stress in the perpendicular direction. The breaking strength of the test specimen was recorded from the Amsler testing machine, and the effect of the compressive stress on the final strength of the joints was interesting.

The results of the experiment have led us to draw the conclusions that within the scope of the preliminary experiment the compressive stress caused by the jig had no remarkable effect on the breaking strength of the fillet joints if the joints were welded with a nominal size of fillet weld recommended for the material and the thickness of the steel plate to be welded. When the size of the fillet weld was made smaller about half the nominal size the existence of the compressive stress showed a tendency to decrease the breaking strength of the specimens to some small extent as long as the compressive stress was not too large. This was so even when the sign of the stress was reversed or when the size of the test specimens was changed. However, it is hard to find out an experimental formula to explain the relationship between the magnitudes of two-axial stresses and the final strength of the welded joints.

Development of Light Gauge Steel Construction and Pipe Construction in Japan

By Ryo TANABASHI and Kiyoshi KANETA

Memoria del II simposio Panamericano de Estructuras. 12–18 Enero 1964, Lima Peru, Vol. 2, July 1965, pp. 796–844.

Abstract

This paper was presented at the Second Panamerican Symposium on Structures held on January 12–18, 1964, at the National University of Technology, Lima, Peru. In this paper was included a historical review on the development of light gauge steel as well as tubular steel constructions from the point of view of building economy and technology. The current building codes and standards prevalent in this country were also introduced, and an interesting feature inherent to the constructions was illustrated with a number of examples existing in this country.

Demands for earthquake-proof and typhoon-resistant structures is especially strong here because this country is located in a very active earthquake and typhoon zone. The building technology of the constructions has, therefore, been developed with a pretty conservative design basis. The materials, shapes, details and the erection of the steel structures are well examined for every individual project. Comments on the fabricating machines were added and a discussion was made in the paper on some ideas and examples of the joints, the ways of assembly of the composite structures in detail, most of which were based on the careful analyses and experiments carried out here for the past ten years.

On the Stress Concentration Observed on Castellated Beams

By Ryo TANABASHI, Kiyoshi KANETA and Ryoichi ANDO

Technical Reports of the Architectural Institute of Japan, Kinki Branch,
May 1965, pp. 65-68.

Abstract

With the purposes of the economical use of structural steel and to make a layout of facilities for air conditioning and ventilation, many recent steel structures have beams with holes on the web, through which a number of piping systems are installed. As an example of the open web beams, circular holes are made on the web of steel beams of I-sections at the locations where design flexural as well as shear stresses are relatively small. The circular holes are reinforced with tubular sleeves built in the perpendicular direction with respect to the londitudinal axis of the beam. Another example of the open web beams being popular in this country is castellated beams.

A castellated beam is made by the process of cutting the web of an I-section —— or a wide flange —— of rolled steel shape along a zigzag line just as if to stitch the neutral axis of the beam, separating the beam into two parts and welding them to assemble a new beam with a higher depth. After the welding process has been finished the beam can be used as an open web beam with hexagonal holes located on the web at an equal distance along the londitudinal axis of the beam. The history of castellated beams in European countries and the United States is long while the appearance of this type of beam is relatively new in Japan.

This paper has investigated the relationship between the curvature at the corners of hexagonal holes and the stress concentrations observed by a photoelasticity experiment. An epoxy resin model including three hexagonal holes was built to have one third scale of a prototype. One end of the model was fixed to the base and the other end was left free and was acted upon by a static lateral load. The model had a different combination of shear and bending moment at each hexagonal hole and the concentrated stresses were clearly observed. It was concluded that when the radius of curvature at the corners of the holes has been increased to about 0.4 inches on the prototype the concentrated stresses were decreased to an appreciable extent and that the radius of curvature might be acceptable in practice with respect to the design and welding workmanship.

Vibration Tests on Kyoto Tower Building

By Ryo TANABASHI, Kiyoshi KANETA and Seiji WATANABE

Transactions of the Architectural Institute of Japen, Special Volume,
September 1965, pp. 119.

Abstract

This paper reports on the results of vibration tests carried out during the construction of Kyoto Tower Building. The 9-story building is located in front

of the Japan National Railway's Kyoto Central Station and exists on a firm gravel foundation. The structure is composed of high tensile, weldable steel and light-weight gravel concrete for the parts above the ground level, and the basement of the building is of ordinary reinforced concrete construction. A unique feature of this building is that it has a large steel tower of about 100 meters in height built on the roof. Therefore, the oscillatory characteristics of the building and the tower as a whole were of great interest from the point of view of structural engineering.

In order to clarify the natural period of vibration of the oscillatory system and the corresponding modes of vibration, a number of field measurements were carried out at different construction stages when the building project was not inaugurated, when the composite ferro-concrete frame was completely erected, and when the building was almost finished, and when the building and the tower were both completed. The results of the field tests have shown us that the natural period of vibration of the building became longer as the construction proceeded and the net weight of the building has been increased. A period of 0.10—0.12 sec was observed as a predominant period of the ground and this is coincident with a period of the building in a higher mode of vibration. It was reported that the building and tower system has the periods of the fundamental, and the higher modes of vibration being 1.2—1.3 sec, 0.45 sec and 0.22 sec, respectively.

Optimum Transfer Matrix of Multi-input and -output Linear System

By Takuji KOBORI, Ryoichiro MINAI and Yoshihiro TAKEUCHI

Proc. of the 2nd Japan National Congress for Natural Disaster Science, Oct., 1965, pp. 189–192.

Abstract

As far as a single-input and-output linear system is concerned, the optimum transfer function which satisfies the prescribed statistical relation between the input and output, has been broadly investigated in the field of control engineering, whether the stochastic processes are stationary or not. In the field of structural engineering, this concept might be applicable to detecting the dynamic characteristics of a structural system by measuring the structural random responses caused by the micro-tremor of the ground, or the wind force. In this case, however, the structural system should be considered, in general, to be a multi-input and-output system, since the local dynamic characteristics of the structural system, or the distributions of dynamical coefficients, have to be detected by measuring the responses of each part of the structural system subjected to multiple excitations.

In this paper, as a statistical method of determinig the dynamic characteristics, the optimum transfer matrix of a multi-input and -output system is presented by extending the Wiener-Levinson formula of the optimum transfer function of a single-input and -output system. Assuming the stochastic processes are stationary, the simultaneous integral equations to define the optimum impulsive respose matrix having Physical realizability, can be obtained by using the least mean square error criterion. Solving these equations in the frequency domain, the optimum transfer matrix of the multi-input and -output system is obtained as an integral form, which contains the cross-spectral density matrix between the input and output, and the non-singular matrices determined by factoring the diagonal elements of the input spectral density matrix. It has been noticed that the same number of independent input-processes are as necessary as the number of inputs, to determine completely the optimum transfer matrix of the multi-input system, and that in the case where the complete number of the inputs is not available, only the necessary conditions for the optimum transfer matrix can be obtainable.

Ground Compliance of a Rectangular Foundation on an Elastic Ground (Rotation about a Horizontal Axis)

By Takuji KOBORI, Ryoichiro MINAI,
Tamotsu SUZUKI and Kaoru KUSAKABE

Transactions of the Architectural Institute of Japan, Extra, Sept., 1965, p. 123.

Abstract

It has been broadly recognized that the earthquake response of structures is greatly influenced by the properties of the ground. We cannot say, however, that the dynamical effect of the ground on the earthquake response of structures is made sufficiently clear. In order to find out these relations, we must, first of all, examine the dynamical properties of the ground, and then by making use of these results, investigate the dynamical behavior of a structure on the ground as a coupled system. As a basic study, one of the authors presented the analytical solution, representing the dynamical response of a rectangular foundation on an elastic half-space, in the cases of vertical and horizontal translation and rotation about a horizontal axis. Moreover, the numerical evaluations for vertical and horizontal translation have been already completed.

In this paper, the numerical evaluation for the rotational case is developed. The solution is represented by the ratio of the foundation displacement to a harmonic distubing force, which we call "ground compliance" of a rectangular foundation. It is the transfer function of the ground that represents the dynamical properties of the foundation on an elastic ground. It depends on the ground constants, the shape and dimension of the foundation area, and the frequency of a disturbing force.

The result is expressed by the complex number involving the residue term around the Rayleigh Pole. Its imaginary part is concerned with energy dispersion to the ground from a source at the surface, and this energy dispersion is much less in the range of low frequency. The residue term is concerned with the Rayleigh Wave, and we can find that it occupies most of the imaginary part, i. e. most of the energy dispersion is caused by the surface waves in the case of rotation. Making use of ground compliance as an equivalent ground characteristic, we can perform the response analyses of structural systems by taking into consideration of the ground effects.

Dynamical Characteristics of Structures on an Elastic Ground

By Takuji KOBORI, Ryoichiro MINAI,
Tamotsu SUZUKI and Kaoru KUSAKABE

Transactions of the Architectural Institute of Japan, Extra, Sept., 1965, p. 124.

Abstract

In this paper, the dynamical characteristics of various types of structural systems on an elastic ground are investigated, considering the horizontal translation and the rotation of its foundation, and in particular, the effect of the rotation on the dynamical responses of the structure is estimated. The concepts designated as the ground compliance for horizontal translation and that for rotation about a horizontal axis are made use of as the dynamical characteristics of a foundation on an elastic ground. It is assumed that the structure has a rectangular foundation and that a harmonic horizontal wave is incident upon the structural system from the ground. The dynamical characteristics of a continuous shear type structure on a square foundation are especially investigated in the case of Poisson's ratio of the ground, $\nu=1/4$. Amplitude characteristics for the rotational and translational displacements of the foundation and for the translational displacement at the top of the structure are shown in graphical representation.

Results are as follows; (1) Though resonance occurs infinitely many times, the value of the amplitude characteristics at resonance is much larger for the fundamental natural frequency that for the higher. (2) If the rotation of the foundation is taken into consideration, the fundamental natural period of the structural system extends. (3) When the ratio of the height of the structure to its width becomes large, the dynamical characteristics of the structure are apt to be affected by the rotational displacement of its foundation. (4) Phase characteristics of the rotational displacement of the foundation and those of the translational displacement at the top of the structure vary rapidly in the neighbourhood of resonant frequencies, from in-phase to out-of-phase or from out-of-phase to in-phase, with reference to the phase of the ground motion. (5) Phase characteristics of the translational displacement at the center of the foundation vary from in-phase to out-of-phase at a little lower frequency than the resonance point, and then back to in-phase again.

On Rocking Vibrations of Rectangular Foundation

By Takuji KOBORI, Ryoichiro MINAI,
Tamotsu SUZUKI and Kaoru KUSAKABE

Reports of the Architectural Institute of Japan (Kinki Subdivision)
May, 1965, pp. 137-140.

Abstract

This paper consists of two parts. (1) The dynamical characteristics of a rectangular foundation on an elastic half-space is estimated by the ratio of the foundation displacement to a harmonic disturbing force, which is defined as "ground compliance" of a rectangular foundation. The numerical evaluation of ground compliance for rotation about a horizontal axis is carried out. (2) Considering the structure and the ground as a coupled structural system, the dynamical characteristics of a one-dimensional, continuous, bending type system on an elastic ground are studied. The ground compliance for horizontal translation and rotation about a horizontal axis are considered as the dynamical characteristics of the three-dimensional elastic ground.

Results of the numerical evaluation of ground compliance are as follows; 1) The real and imaginary parts of ground compliance are evaluated as a function of frequency of a disturbing force. And the results are shown in graphical representation. 2) In the case of rotational ground compliance most of the imaginary part is represented by the residue term at the Rayleigh Pole. This corresponds to the phenomenon that most of the energy dispersion to the elastic ground is caused by the Rayleigh Wave.

Results of the analysis for the coupled ground-structure system are as follows; 1) Though resonance occure infinitely many times as the frequency parameter is varied, the value of amplitude characteristics at the fundamental natural frequency is much larger than the value at the higher natural frequencies. 2) If the rotation of the foundation is taken into consideration, the fundamental natural period of the structural system extends. 3) As the ratio of the height to width of the structure becomes larger, the dynamical characteristics of the structure system are largely affected by the rotational ground compliance.

Statistical Properties of Earthquake Accelerograms and Equivalent Earthquake Excitation Pattern

By Ryo TANABASHI, Takuji KOBORI,
Kiyoshi KANETA and Ryoichiro MINAI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 2, Feb., 1965, pp. 49–68.

Abstract

In order to analyse the earthquake responses of structures, first of all, it is very important to reasonably predict an earthquake excitation pattern by referring to the model of a structural system, and the measures of aseismic safety. It is impossible to know the excitation properties of future earthquakes, so assuming that future earthquakes will have approximately the same properties as past earthquakes, it is necessary, first, to analyse the properties of the accelrograms of past earthquakes. Most of such accelerograms are of a likely random time function. And their statistical quantities, in details, differ from each other, depending upon the individual characteristics of the past earthquake, the recording place of accelerograms, and the other conditions.

In this paper, the auto-correlation functions, and amplitude probability density distribution functions, are estimated from a number of past strong earthquake accelerograms. It is also shown that an earthquake accelrogram has the spectral density, with a few peaks and non Gaussian probability density distribution. On the other hand, the statistical model for the equivalent earthquake excitation pattern is presented, by considering the common properties based on the above statistical results. Although it is difficult for the earthquake response analyses to give the dimensional quantities —intensity, standard frequency of frequency characteristics, and so on,— of earthquake excitations depending on individual soil conditions, the dimensionless parameters which define the statistical model of the equivalent earthquake excitation pattern, can be determined in the case that the influence of the ground-structure coupling, is small. Then it is found that the spectral density of simplified equivalent earthquake excitation patterns may consist of the band limited white noise spectrum, and the delta functions, corresponding to a noise component and periodic components.

As an additional remark, it should be noted that this paper was presented to the First Chilean Sessions on Seismology and Earthquake Engineering held in July, 1963.

Method of Earthquake Response Analysis of Frame Structure Having Elasto-Plastic Joints

By Takuji KOBORI, Ryoichiro MINAI and Masanori IKEDA

Proc. of the 2nd Japan National Congress for Natural Disaster Science,
Oct., 1965, pp. 177–180.

Abstract

In regard to the ultimate elasto-plastic aseismic design method, the earthquake response analyses, to obtain the pertinent aseismic design data for the initial structural design of elasto-plastic structures, have already been carried out in the wide ranges of parameters which are concerned with the structural systems and earthquake excitations. In this stage of analysis, both of the models of the structural systems, and measures of aseismic safety, have been supposed to be general and comprehensive. To estimate more precisely the aseismic safety of the elasto-plastic structure, which is designed individually by the abovementioned aseismic design data and other structural design data, and to improve the aseismic design data already obtained in the foregoing analysis, the more detailed response analysis should be developed by making use of the more concrete structural model, composed of the local dynamic characteristics of the structural system, and the local measures of aseismic safety of structural elements.

In this paper, the methods of earthquake response analysis of a frame structure having elasto-plastic joints are discussed. The model of the structural system is supposed to be an elasto-plastic, lumped mass system of which restoring force characteristics are set up by the dynamic characteristics of the elasto-plastic joints and the elastic members. As the local measures of aseismic safety, the ductility factor and the dissipated hysteretic energy ratio of each elasto-plastic joint are considerd, defining them as the ratio of the elastoplastic relative rotation between both sides of the joint to its elastic limit relative rotation, and the ratio of the total dissipated hysteretic energy of the joint to its elastic limit potential energy, respectively. Based on the fundamental vector-matrix equations which are derived from the dynamic equilibrium of lumped masses, and the continuity of bending moments of the elasto-plastic joint and the adjacent elastic member, either of which are expressed by their relevant force-deformation characteristics, the numerical step-by-step solution procedure for a digital computer and the simulation method for an analog computer are presented.

Eathquake Response of the Structure Considering the Effect of Ground Compliance (2 nd Report)

By Takuji KOBORI, Ryoichiro MINAI and Yutaka INOUE

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 8, March, 1965, pp. 193–218.

Abstract

The method of transient, nonlinear response analysis of a coupled ground-structure system, subjected to earthquake excitations is presented. The model of the above-ground structure and the adjacent subsoil (boundary layer) is supposed to be a multi-degree-of-freedom, shear type system, having bi-linear hysteretic characteristics, and that of the elastic ground is represented by a linear transfer function, having the form of a rational function which is derived from the ground compliance of a foundation.

First, the analytical expressions of the impulsive response matrix, and the general solution in arbitrary linear branch of the structural system are given by considering the complex eigenvalue problem. It is of interest that the time factor of the impulsive response matrix contains the sinusoidal functions, having phase angles varied with spatial variables. In particular, the numerical values of complex eigenvalues and corresponding normalized eigenvectores, which are concerned with the initial elastic branch of the structural system, are calculated. Then, the natural frequency and equivalent critical damping ratio of each of the harmonics are evaluated from the complex eigenvalues. It has been noticed that the sequence of the equivalent damping ratios, due to the dispersive elastic ground, has its own peculiar characteristics.

Second, the transient, non-linear responses of the structural system, subjected to random excitations, are analysed by making use of an analog computer, in the wide ranges of dimensionless parameters, with regard to the excitation and the lower sub-structure. As a result, the maximum values of the non-dimensional relative displacements, and the overturning moment ratio, are shown in the response diagrams. Because the stiffness and strength parameters of the boundary layer are chosen to be rather larger than those of the above-ground structure, the dynamic characteristics of the sub-structure do not affect noticeably, the responses of the above-ground structure, in spite of considerably wide variations of the parameters of the elastic ground. However, it has been shown that the response of the boundary layer, and the elastic ground, are largely affected by their relevant parameters, and that the responses of the above-ground structure are influenced strongly with the frequency and strength parameter of the dimensionless excitation.

Statistical Responses of Linear Systems Subjected to Non-Stationary Random Excitations

By Takuji KOBORI, Ryoichiro MINAI and Yoshihiro TAKEUCHI

Proc, of the 2nd Japan National Congress for Natural Disaster Science, Oct., 1965, pp. 181–184.

Abstract

In general, structures would be desingned reasonably, according to the elastic, statistical aseismic design method against the moderately intense earthquakes with a large frequency of occurrence. The earthquake excitations are essentially random and non-stationary, and the transient responses of the elastic structure are affected strongly by the spectral characteristics of the excitations. So the earthquake response analysis should be performed statistically as the problem in the non-stationary, stochastic process. Then, the output response of the structure must be chosen to be the statistical measure of aseismic safety, that is, for instance, the average number of exceeding the allowable response level, or the probability of peak amplitude over the allowable response level. When the stochastic process is Gaussian, these statistical quantities can be evaluated from the covariance, or the corresponding spectral density defined in the non-stationary process.

In this paper, as the statistical quantities of the input and output of the time-variant linear lumped system, the covariance matrix, and the spectral density matrix in the non-stationary stochastic process are only considered under the assumption of the Gaussian process. At first, two-dimensional local spectral density matrix is defined as the double Fourier transform of the local covariance matrix being zero out of the prescribed bounded domain. Then, three kinds of one-dimensional, local spectral density matrices are derived from the above-mentioned spectral density matrix and each of them is related to the local covariance matrix as the pair of Fourier transform. All of these local spectral density matrices can be expressed as the weighted averages of the corresponding full spectral density matrix defined by the double Fourier transform of the covariance matrix in infinite domain. Moreover, the input-output relation of these statistical quantities in the non-stationary process are determined. Particulary, in the case of a time-invariant linear lumped system, the input-output relation of the full spectral density matrix is reduced to the formula established by Dr. J. S. Bendat.

Non-Linear Earthquake Response of the Elasto-Plastic Structural System Considering the Effect of Dynamical Compliance, No. 2

By Takuji KOBORI, Ryoiɔhiro MINAI,
Yutaka INOUE and Teruo KAMADA

Transactions of the Architectural Institute of Japan, Extra summaries of technical reports, Sept., 1965, p. 125.

Abstract

It has been recognized among earthquake engineers, that the dynamic characteristics of the ground have a great effect on the earthquake response of a structure. So it is important and necessary to estimate reasonably this effect on the behavior of the above-ground structure.

In this paper, the dynamic characteristics of the ground are expressed approximately by the ground compliance derived theoretically from the relationship between the applied force and the displacement response of the center of a rigid foundation on a half-space elastic ground. A study is done on the effect of such dynamic characteristics of the sub-structure and ground on the earthquake response of the above-ground structure. As the assumption of this study, the above-ground structure is supposed to be one degree of freedom system, with the bi-linear hysteretic restoring force characteristics. The same characteristics are also given for the boundary layer, which represents the effect of the sub-soil surrounding the sub-structure. The dynamic characteristics of the ground on which the structure rests, are expressed by the transfer function of rational function depending on the dynamical ground compliance.

As to the wave shape function of earthquake acceleration, we adopt the wave form obtained from the output of a noise generator that is equivalent to a stationary Gaussian random time function with tha band limited white spectrum. The analysis herein is done in the wider domain of the parameters than that of previous analysis by means of an electronic analog computer.

Non-dimensional equations of motion of the coupled ground-structure system are presented together with various parameters of this system. A brock diagram for the analog computation is illustrated. And the maximum non-dimensional relative displacement of the above-ground structure is also illustrated as one of the results.

Analog Computer Analysis of Non-linear, Transient Vibration of Structures (Fifth Report)

By Takuji KOBORI, Kiyoshi KANETA, Ryoichiro MINAI,
Koji MIZUHATA and Yutaka INOUE

Proc. of the Thirteenth Japan National Congress for Applied Mechanics
published in March, 1965, pp. 290-294.

Abstract

For the establishment of the reasonable method to design anti-seismic tall building structures, it is most important to know how such structures vibrate during earthquakes. Then the response analysis of some idealized structural models, subjected to various kinds of seismic waves, has been studied recently. In this paper, the transient response analysis of a tall building structure is presented by applying idealized seismic waves on a five-mass-spring system. The spring used is assumed to have the characteristics of the bi-linear hysteretic type. The seismic wave applied on the structural model, consists of the simple harmonic waves with the various values of period, since a higher mode of vibration is apt to be predominant in a tall building structure. The assumed seismic wave is composed of four cosine waves, each of which has the same period as "the first to the fourth" vibration period of the elastic system respectively. Here,two kinds of seismic waves are supposed to be. In one case, each amplitude of the cosine waves is inversely proportional to the individual period —— all of the maximum velocities have a constant value. In the other case, each amplitude is inversely proportional to the square of the individual period —— all of the maximum displacements are constant. Various responses, —— various mode shapes, and various displacements, —— are analyzed by using an electronic analog computer, and they are investigated in terms of the ductility factor.

As expected, the shapes of the mode of vibratory response seem to be of a complex figure composed of the third and the fourth vibration modes, and the values of ductility factor at each story level are almost similar. The assumed structural system then appears to have proper dynamic characteristics for the excitation used here. There are, however, such ranges in which the values of the ductility factor is reasonable, and its variation with the parameters is small, since the responses are largely affected by the amplitude and the frequency of the excitation.

Non-Linear Earthquake Response of the Elasto-Plastic Structural System Considering the Effect of Dynamical Compliance, No. 3

By Takuji KOBORI Ryoichiro MINAI,
Yutaka INOUE and Teruo KAMADA

Transactions of the Architectural Institute of Japan, Extra summaries of techical reports, Sept., 1965, p. 126.

Abstract

The effect of the dynamic property of the sub-structure and sub-soil ground should be considered in the earthquake response analysis of a building structure. The transient non-linear response of the coupled ground-structure system, subjected to the random excitation used in the previous paper, is analized here by means of an electronic analog computer.

Maximum non-dimensional relative displacement of the above-ground structure, the boundary layer and the elastic ground is defined as an important measure of anti-seismic safty. The results of this relative displacement are illustrated for various parameters, which represent the dynamic property of this system.

The main effect on the response of a structure depends upon the strength and the frequency of the excitation, respectively. In the domain of parameters considered here, it seems to be hopeless to find the distinguished effect of the sub-soil ground property on the response of the above-ground structure. General tendencies of the results for each parameter, however, show that the dynamic property of the sub-structure and ground must be essentially estimated in case the dynamic stiffness of a structure is relatively greater than that of the sub-soil ground. The greater the ratio of the mass of the sub-structure, to that of the above-ground structure becomes, the larger plastic behavior of the boundary layer is observed. The elongation of the fundamental natural period of the coupled system, compared to that of the non-coupled above-ground structure system, has a great effect on the response of the elastic ground. In this case, the large displacement of the elastic ground occurs. The relation between the response and the frequency ratio —— excitation frequency / system frequency —— shows that the large frequency ratio makes the relative displacement response of the above-ground and of the boundary layer smaller, and also that the displacement response of the elastic ground, however, is nearly constant for most of the frequency ratio value.

Effect of Ground Compliance on Dynamical Response of Structure

By Takuji KOBORI, Ryoichiro MINAI,
Yutaka INOUE, and Teruo KAMADA

Reports of the Architectural Institute of Japan (KINKI Subdivision)
May, 1865, pp. 133–136

Abstract

In order to know the dynamical behavior of the building structure during earthquakes, it is necesary to appropriately estimate the dynamical property of the under-ground and sub-soil structure as well as that of the above-ground structure. In this paper, the authors discuss the earthquake response of the elasto-plastic coupled ground-structure system with the dynamical ground property that is so-called ground compliance (approximately expressed as the rational transfer function) of the under-ground and sub-soil structure.

This dynamical response analysis is treated by analog computer techniques, and ground compliance theoretically calculated as the dynamical characteristics of an elastic half-space ground is approximately expressed by the binominal rational transfer function instead of the conventional spring-dashpot representation. For this coupled structural system the earthquake excitation used herein is to be the band limited white noise applied on an electronic computer by a noise generater through a band-pass filter. The output responses of this system are to be the several maximum non-dimensional relative displacemants and absolute accelerations. As the results of such analysis, we found the general effect of ground compliance on the elasto-plastic response of the above-ground structure.

Earthquake Response of a Certain Elasto-plastic Structure

By Takuji KOBORI, Ryoichiro MINAI,
Toshiharu HISATOKU and Yutaka INOUE

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 8,
March, 1965, pp. 219–233.

Abstract

In this paper, the anti-seismic safety of the sixteen-story and/or twenty-story steel-frame office building, designed on the basis of the conventional anti-seismic building code, is discussed from the standpoint of the earthquake responses, in order to obtain more reasonable structural design of such a steel frame type of building structure.

The structural model analyzed here is assumed to be a five or seven mass-spring system, with bi-linear hysteretic restoring characteristics, specified by the designed initial rigidity and elastic limit strength. The ratio of secondary rigidity to initial rigidity is to be twenty percent and the critical viscous damping ratio to be two or five percent except zero. The input earthquake data taken from two different types of the following typical ground acceleration records:

El Centro Earthquake, NS component and EW component, May 18, 1940.

Vernon Earthquake, S82°E component, Oct. 2, 1933.

The basic parameters which are varied mainly in this analysis, are the acceleration amplitude and time duration of those earthquakes, except the above-mentioned rigidity and damping ratio of the structural system. All results of earthquake responses under the analog computation are presented in the form of graphs showing the distribution of maximum ductility factor of each model, for various combinations of the basic parameters.

Earthquake Response Analysis of an Actual Building Structure

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE,
Toshiharu HISATOKU and Teizo FUJIWARA

Reports of the Architectural Institute of Japan (KINKI Subdivision)
May, 1965, pp. 129–132.

Abstract

It is very important for earthquake engineers to discuss frequently about the anti-seismic safety of an actual tall building structure. The one-span, sixteen-story steel frame building, scheduled for construction on the firm ground, is analized in this paper. First of all this building structure is assumed to be an elasto-plastic structural model of six degrees of freedom system with the bilinear hysteretic characteristics, for the purpose of the earthquake response analysis. Secondly the ratio of the initial elastic shear rigidity to the secondary plastic shear rigidity, is to be evaluated as ten percent, and the critical viscous damping ratio to be about two percent, for this steel frame structure. Also, the maximum value of earthquake ground acceleration records used in this analysis is to be from ten percent to forty percent times of gravitational acceleration, and the time-duration of these ground acclerations are to be from two thirds, to one and a half times of each original record duration.

As the results, it can be pointed out that anti-seismic safety of this tall building structure is sufficiently estimated from the response analysis. For instance, the maximum response value of the ductility factor becomes from one to three. Along the height of this building, the maximum response of the ductility factor is larger at fourth story level, and smaller at fifth or sixth story level, under the actual condition of the dynamic property, represented by the distribution of initial elastic rigidity, elastic limit strength and shear coefficient. The structural design is proved to be more economical when the distributed shear coefficient becomes smaller by making the dynamic property distribution more reasonable. As to anti-seismic safety of the ground condition, the dynamic response of overturning moment is calculated in this analysis and shows about two thirds of allowable value.

Effect of Structural Model on Earthquake Response

By Takuji KOBORI, Ryoichiro MINAI,
Yutaka INOUE and Toshiharu HISATOKU

Transactions of the Architectural Institute of Japan, Extra summaries of Technical Papers, Sept., 1965, p. 136.

Abstract

Anti-seismic safety of a building structure and degree of pertinence of distribution of its dynamical characteristics, need to be examined with the transient earthquake response analysis. For the purpose of knowing the details of vibration of a building structure during earthquake, and the variation of response with the parameter related to earthquake excitation, the tall building structure with underground structure, which is designed with the Japanese anti-seismic code, is idealized to a spring-mass system with the restoring characteristics of a non-linear hysteretic type. Earthquake response of the system is analyzed by an electronic analog computer.

Several records of past strong motion earthquakes, are adopted for the study as wave pattern of earthquake excitation in time series. To investigate the distribution of response in the structure in detail, the structural system is assumed to be three kinds of five-mass systems with viscous damping. Moreover, in one case, the upper part of the structure, which was a three-mass system at first, is reformed anew into a five-mass system, and it is subjected to the acceleration response in the fixed co-ordinate of under-ground structure of the former structural system, as earthquake excitation. The variation of maximum ductility factor is investigated in the range which is determined dy the maximum ground acceleration, varying from 0.1 to 0.5 times of gravitational acceleration, and by the duration of ground motion, varying from two thirds to one and a half times of the original record duration.

Generally, the larger the intensity, or the longer the duration of earthquake excitation is, the greater the response of a structural system becomes. Each structural system is idealized in several different ways. Although the mean values of the maximum ductility factor of the same story of each structural system are similar, it is shown that the distributive characteristics of them differ partially from each other. On the other hand, when the structural system has a little internal viscous damping, the response is uniformly restrained from increasing greatly, and the deviation of the response from the mean value of each system is seen to be small.

On Determination of Linear Transfer Function Matrix of Multi-degree of freedom System

By Takuji KOBORI, Ryoichiro MINAI,
Yoshihiro TAKEUCHI and Masahiro KAWANO

Proc. of the 2nd Japan National Congress for Natural Disaster Science,
Oct., 1965, pp. 185-188.

Abstract

The authors discuss in this paper, the statistical determination procedure of the linear transfer function matrix, of multi-degree-of-freedom system, with the idealized dynamic characteristics to an actual building structure. The linear transfer function matrix of this system subjected to independent multi-input of the individualy known spectral density, can be determined theoretically from the relationship between input and output spectral density.

On the other hand, the input and output data measured in an actual structure have generally some various combination properties of the useful signal and the noise, although the statistical characteristics of noise signal can be anticipated in most case. Applied to the filtering problem, it is shown that the useful signal can be theoretically separated from the noise, by calculating auto- and cross-spectral densities of both input and output data.

Here, as a simple application of the statistical determination of transfer function, an analogue computation is carried out in the case of one-degree-of-freedom system, using input of the nominal band limited white noise. Before its computation, the period and damping of this system should be estimated. Then it is examined whether the characteristics of this system are determined or not, from the auto-correlation functions and spectral densities of the input and output.

As a result, although the spectral density of the nominal band limited white noise is considerably different from that of the so-called band limited white noise on account of the specific properties of a noise generator, and a band pass filter, the characteristics of the system are shown clearly in the spectral density of output only. From this standpoint, it can be justified to regard input as white noise, under the circumstances where the input is comparatively random.

On Structural Random Response

By Takuji KOBORI, Ryoichiro MINAI,
Yoshihiro TAKEUCHI and Masahiro KAWANO

Proc. of the 2nd Japan National Congress for Natural Disaster Science,
Oct., 1965, pp. 181–184.

Abstract

In the case that the time-dependent property of output responses of an unknown system subjected to the statistically known property of input random excitations is statistically given, the optimum transfer function of such a system is, in principle, to be determined as in the synthesis problem of the automatic control system. In this paper, the application of Nobert Wiener's procedure is presented to determine the unknown dynamical property of a structural system to random ground excitations. In this case, the input yielding to the stationary random process is given by the ordinary ground tremor, and the output structural response is randomly excited by its ground tremor.

First of all, it is found that the optimum transfer function of this structural system is introduced from a procedure which minimizes the mean-square error between the output of the measured structural response and that of the supposed transfer function, according to the physically realizability condition. Secondly, that after calculating the auto- and cross-correlation function of input and/or output, the useful signal is easily produced by means of eliminating the useless noise signal from the instrumentally measured records. Finally, the numerical example of this analytical problem is shown as in the case of one degree of freedom structural system subjected to random excitations, and correlation functions or spectral densities between input and output are calculated herein.

Statistical Analysis of Seismic Waves

By Takuji KOBORI, Ryoichiro MINAI and Yoshihiro TAKEUCHI

Proc. of the thirteenth Japan National Congress for Applied Mechanics Publised in March, 1965, pp. 295-300.

Abstract

Recently the writers have discussed about some basic characteristics of seismic waves, through the statistical analysis of several ground acceleration time-records in order to find the various essential quantities of the generalized input that means the generalized ground acceleration applied on the structural model in the earthquake response analysis.

It is difficult to clarify explicitly the characteristics of seismic waves, which is necessary for the dynamic analysis in earthquake engineering, on account of the scale, the mechanism of the earthquake, the frequency of occurrence and so on. On perfoming the statistical research however, we can deduce to some extent the various properties of seismic waves from the recorded accelerograms. In such a research, treating of only a few recorded accelerograms as an ensamble for deriving the local characteristic of seismic waves, will come into question; the characteristics had better be defined as a time series.

When recorded accelerograms are used for the analysis, they should be regarded as the response of waves propagated from the seismic origin. It is therefore, necessary to take into consideration the coupling of structure with subsoil ground, in order to estimate the recorded accelerogram appropriately. This also implies that the analysis of the recorded accelerogram is useful not only to estimate the generalized input pattern for the structure, but also to clarify the coupling characteristics of the system consisting of the structure and subsoil ground. From this point of view, we have computed, in the first stage, the autocorrelation function and the amplitude probability density distribution function for four accelerogams of two kinds of earthquake records;

El Centro earthquake (1940), N-S component and E-W component and Vernon earthquake (1933), S82°E component and N08°E component.

Surface Winds of Typhoon Wilda (6420) over Japan

By Ryozaburo YAMAMOTO, Yasushi MITSUTA,
Kenji MIYATA and Makoto TAHIRA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 593-604.

Abstract

Wind storm caused by Typhoon Wilda (6420) which passed over western Japan on 24 and 25 Sept. 1964 is studied. The typhoon central pressure on the coast of Kyushu was about 940 mb. The observed maximum wind speed distribution was analysed in comparison with computed maximum gradient wind speed distribution and with the distribution of wind damages. These three kinds of distribution patterns are alike in shape to each other. Strong winds and severe wind damage of houses are seen on the right of the pressure center path, and the axis of this high wind zone was estimated to be about 30 or 50 km east from the center path. But most of this axis was off the seashore of the main islands of Japan, and wind disaster was relatively small compared to its deep central pressure.

A prominent feature of wind speed records of this typhoon is the extraordinary large peak gust speed of 72 m/sec observed at Uwajima, which was on the left of the typhoon path. This wind peak was isolated from the high wind zone on the right of the path. The existence of a small disturbance in the typhoon, is proposed in this paper, as the explanation for the reason of th extraordinary winds.

Standard Project Typhoon (1)

By Yasushi MITSUTA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp. 605-612.

Abstract

This is the first report of a study to provide generalized typhoon specifications that are consistent geographically and meteorologically, for use in planning, evaluating and establishing design criteria for typhoon protection works. The Standard Project Typhoon, which is analogous to the Standard Project Hurricane in the United States, is defined, and its indices are derived based on the statistical analsis of past typhoons in this first report.

The areas where typhoon disasters should be considered, are studied from typhoon storm frequencies in the past thirty years. They are concluded to be Kanto Area, and other areas west from it. The central pressure of typhoon on the coast is chosen as the index which defines the intensity of typhoon. And occurence probability of central pressure on the coast from 1927 to 1961 is studied. The central pressures which correspond to the occurence probability of once per 100 years for each area, are as followings: Kyushu 924 mb, Shikoku 923 mb, Kinki 922 mb, Tookai 942 mb and Kanto 942 mb. Besides these, the radius of maximum wind speed, direction and speed of typhoon movement on land, and filling of central pressure on land, are also studied as the indicies which specify the characteristics of typhoons hitting the Japanese Islands.

A Study on the Variation of Low Flow

By Tojiro ISHIHARA and Fusetsu TAKAGI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 2, No. 95.

Abstract

Many investigators have studied the recession characteristics for the runoff of ground water and proposed some fundamental expressions for the recession curves, almost all of which are only empirical and the physical significance of the expressions can not be explained theoretically.

In this paper, the writers deal with the characteristics of variation of low flow, or ground water run off, from the point of view of the runoff process, and they have derived, theoretically, the equations for the recession curves and the rising state of discharge due to rainfall.

Phenomenological treatment may assume that the runoff discharge of ground water, consists of the seepage components from a confined aquifer and the leakage one from an unconfined aquifer. There are different characters in the kinematical phase between those two components, therefore the low flow may be characterized by these kinematical characters. The writers have dealt with the characteristics of low flow, or ground water runoff, by means of the theoretical discussion of the movement of flow in mathematical runoff models for these components and applied the analysis to the natural river basin.

The results obtained through this research are as follows.

The recession curve of confined component may be expressed by the exponential function, in which the recession coefficient is constant for a river basin. The recession curve of the unconfined component is expressed by the reciprocal function, and the recession rate is much more gentle than that of the confined one. The low flow during the extended period is mainly supplied by the unconfined runoff component. By the discussion, the writers have clarified the role of these components in the runoff process, and the physical significances of many factors involved in the equation.

In the case of the rising state of discharge, the writers have obtained theoretically the relationships between the increment of discharge and storage, duration time of rainfall, and rainfall intensity for the two components. And it has been clarified that the duration time of rainfall plays an important role in the variation of low flow due to rainfall.

Stability of Beaches using Groins

By Tojiro ISHIHARA and Toru SAWARAGI

Proceedings of 9th conference on Coastal Engineering, Lisbon, Portugal,
June, 1964, pp. 299–309.

Abstract

The qualitative studies on the effect of the groin to the littoral sand transport have been conducted by many investigators. However, no study is yet made on how the amount of littoral sand transport, past a groin, changes with time after the installation of the groins.

The scale model test, using movable bed in the laboratory, is very difficult, since the small scale studies in the experiment can not give the exact quantitative evaluation under the prototype condition. Therefore, to clarify the storage capacity of the groin to sand drift, the field investigation have been carried out along the Imazu and Sakano Coasts in Tokushima, Japan.

Beach process, after the installation of groins is discussed theoretically, and the amount of transport past an impermeable groin made of cubic concrete blocks, is compared with the one of a permeable groin made of hexaleg blocks.

The following conclusions have been drawn from the results of this study.

(1) The T-type groins give effective results for the stabilization of the beaches where the direction of littoral drift furiously changes.

(2) The longer T-type groins are constructed when the flatter beach configuration results.

(3) Using the results of the field investigation, the method of estimation of the storage capacity of littoral sand drift for the permeable and impermeable groins, is proposed.

(4) To stabilize beaches by groins, the storage capacity of the groins has to be changed with the locations, so that the amount of transport part a groin is kept constant along the coast.

It is believed that the quantitative results on the storage capacity of sand drifts by the groins, will be valuable when the groin system is used to stabilize beaches.

On Secular Change in Inflows to Lake Biwa

By Masashi NAGAO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, March, 1965.

Abstract

This paper described the characters of the secular change in the inflow into Lake Biwa by the use of the time series analysis, especially its periodicity and randomness, the possibility of the prediction of the future inflow and the climatic factors affecting the annual loss of water, which is the difference between the inflow into the lake and the precipitation over the basin, were discussed.

The summary obtained are the following:

(1) Since the secular change in the winter inflow (Nov. to May) is nearly stationary, that in the annual inflow is mainly due to the summer inflow (Jun. to Oct.).

(2) The periodicity of about 60 years in the secular trend of annual and summes inflow is discerned by correlogram analysis. By fitting a sinuous function to this periodic change, peaks of the annual inflow occur in 1903 and 1960, its trough in 1931, and its amplitude becomes 94 cm in water depth of the lake. No special trend can be found out about the residual inflow which is removed by such a periodicity from the total inflow.

(3) The prediction by the use of the Wiener s theory, based upon a linear combination of the residual inflows, is of little significance in practice from the view-point of predictive error.

(4) Since, owing to the field observation, the secular change in the annual amount of evaporation from the lake surface is not so large, the secular change of the total loss of water will result mainly from the evaporation and the transpiration from the ground and the vegetation in the drainage area surrounding the lake.

(5) One of the dominant factors affecting the secular change in the total loss of water is the insolation, and especially cumulative sun-shine because both secular changes resemble each other.

Study on the characters of flood runoff in the Yoshino River

By Masashi NAGAO

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 8.

Abstract

The purpose of this paper is to show a general approach to disclose the hydrological characteristics of flood runoff in the case where the areal distribution of storm rainfall and the hydrogeological properties of a drainage basin are considerably biased, by the use of an example of the Yoshino River basin which is located in the upstream area of the Kino River, Nara District.

First, study is carried out to examine the several characters of areal distribution of rainfalls, that is, relation between the annual, monthly and total amount of rainfalls and the topographical factors such as elevation or distance from the coastal line in comparison with each meteological cause. Next, geomorphological properties to flood runoff such as the length and slope of the channel and valleyside are analyzed by the topographycal map over the entire watershed. By use of these results, the statistical method to divide the basin into several sub-basins is presented. The divided sub-basin is called a unit-basin, in which it might be assumed that various characters are similar in the view point of runoff analysis during a flood.

The Yoshino River basin, 487 km^2 in area, can be divided into five unit-basins, and the physical characters of flood runoff in the total basin is summarily clarified by synthesizing hydrographs from each unit-basin, which can be calculated by the deduction of the equation of continuity of rain water and the relationship beetween the stored water in the basin and the discharge from it.

Flood Disaster iu San-in and Hokuriku Districts (1964)

By Katsumasa YANO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 3-9.

Abstract

The heavy rain concentrically fell upon the San-in district on the 7 th to the 8 th and the Hokuriku district on the 18 th to the 19 th of July in 1964. Pulviometers recorded rainfall of 200 mm to 300 mm in total. Since the banks of many rivers in these areas were destroyed, the farms and towns were inundated and the facilities for communication and transportation were completely stopped. The total damage of these public work structures was approximately estimated at 20.0 billion yen. Moreover, in Shimane prefecture one hundred human lives were unfortunately lost by landslide.

In this paper, the author explains the outline of the characters of weather, flood and disaster, and gives his opinion on the river planning and management for small rivers and tributaries of a large river, which are the improvement programs of the Hii River, catchment area of which is nearly 1,000 km^2 in the San-in district and the Kuzuryu River, area of which is 2,934 km^2 in the Hokuriku district, and the reclamation project of Kahoku-gata lake with the area of water surface being 22.48 km^2 in the Hokuriku district.

Although the present flood disaster is not so severe with regards to the total amount of rainfall, it sohuld be noticed that such disasters have occured in small rivers and tributaries which have not been improved yet. The author describes the characters of this disaster and points out the necessity that the river planning should be established by taking into consideration such disasters in small rivers and tributaries.

On the Flood Propagation Through Backwater Reach (1)

By Katsumasa YANO, Kazuo ASHIDA and Tamotsu TAKAHASHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 257-270.

Abstract

In this paper, propagation of flood wave through backwater reach which is bounded by a fixed downstream type weir is discussed by the experiments conducted in an experimental flume for flood wave (150 m long, 60 cm wide, 1/500 bed slope)

Flood propagation through backwater reach is generally estimated by the graphical solution of storage equation on the assumption that in this region the water stage changes horizontally. Generally, backwater reach is divided into two regions; one is the storage region near the weir in which the above assumtion is valid, and the other is the transition region from uniform to storage region. And when the transition region plays an important role as in a small reservoir, the above estimation is not accurate.

The authors studied the propagation of flood wave in such a case, and obtaiend the results as follows:

(1) The water stage-time relation curve scarcely changes its shape in the storage region, but in the transition region, during the period of stage increase, the curve has the characteristics as in the uniform region and during the period of stage decrease the curve deforms as in the storage region, and so along some reach of this region the curve has two peaks.

(2) In the backwater reach the stage-discharge relationship generally differs from that of the steady flow and discribes a loop, but when the depth-discharge curve at the weir crest is similar to that of the steady flow in the uniform region, the curve of flood is not so greatly apart from that in the uniform region during the period of discharge increase, so that in such a case the existence of the weir has no important effect to the downstream of the weir on the arrival time or on the attenuation of flood.

(3) The speed of propagation of discharge maximum is given with sufficient accuracy in the uniform and storage region by the Kleitz-Seddon's law, but in the region of transition the propagation speed of flood wave can not be discribed by the Kleitz-Seddon's law.

Furthermore the authors obtained the fundamental equation of flood flow in the uniform region and storage region by discussing the order of terms in flood equation. And by the use of these equations, they deduced an equation which gives the length of the storage region.

Study on Anomaly of Water Level at and near the River Mouth (1)

By Katsumasa YANO and Shigehisa NAKAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 281–296.

Abstract

Study on anomaly of water level is required for protection of structures and for prevention from disasters near and on the coast, especially at the river mouth. There will be several ways to study this subject. In this paper, one of the theoretical methods is developed and some numerical results are obtained. The anomaly of water level is classified into three patterns: i) High waters caused by meteorological conditions, ii) Tsunamis caused by earthquakes and iii) Short period gravity waves and sea-waves. For these three patterns the solution is obtained by the successive approximation from the Navier-Stokes equation and the equation of continuity. This solution gives the decrement of anomalous water level and its propagation velocity upstream from a river mouth.

1) The decrement of anomalous water level is a function of water depth, its representative period as waves, and the velocity of ordinal river-flow. These relations are shown graphically for the solutions of 1 st order and 2 nd order. As a result, the decrement of 1 st order may be sufficient in determining the region affected by the anomalous water level from the river-mouth.

(2) The propagation velocity of anomalous water level as waves is also a function of the same factors as for the decrement of water level. These relations are also shown graphically. As a result, the propagation velocity of anomalous water-level may be sufficient in considering the maximum propagation velocity as waves.

(3) But the solutions are not continuous at $v_0/gh=1$, so that application of these results is not suitable in the vicinity of $v_0/gh=1$ practically. The solutions may be sure mathematically but not sure from view poiut of practical phenomena or physical considerations.

This study is not completed yet. Further study should be carried out refering to the records of anomalous water-levels and by use of model experiments.

Fundamental Study on Mud-flow (V)

By Atsuyuki DAIDO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 317–326.

Abstract

This paper is concerned with the mechanism of a turbulent flow of Bingham fluid. The paper consists of four chapters. In the first chapter, the author discussed the resistance law of the turbulent flow of Bingham fluid in smooth and rough pipes. The relation between the resistance coefficient and the modified Reynolds number proposed by the author is expressed by the logarithmic law similar to that for Newtonian fluid. The coefficient in the law is independent of the variation of characters of the fluids. In the second chapter, the author discussed the velocity distributions in the turbulent flow of Bingham fluid. A velocity distribution and a resistance law of turbulent flows of Bingham fluid in a smooth pipe were derived theoretically and based on the assumption that the mixing length theory can be applied to the expression of Reynolds stresses in flows. It was concluded from the above consideration that the constant in the velocity distribution and expression for the thickness of a laminar boundary layer is expressed by a function of τ_y/τ_0, in which τ_y is the shearing yield stress and τ_0 the boundary shear stress, because the coefficient in the resistance law is constant.

In the third chapter, tha same calculation as described above was carried out in the case of an open channel. In the fourth chapter, the author considered the kinetic similitude of the Bingham fluid. The kinetic similitude was defined that the ratio of the shearing yield stress and the kinetic inertia of flow, the Reynolds and the Froude number of flow respectively become constant in both flows in a model and a prototype. It was concluded that the kinetic similitude can be expressed by the two dimensionless parameters, the ratio of the shearing yield stress and the kinetic inertia of flow and the Reynolds number, for a practical purpose.

Fundamental Study on Mud-flow

By Katsumasa YANO and Atsuyuki DAIDO

Bulletin, Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 2, February, 1965, pp. 69–83.

Abstract

This paper deals with the deformation and flow of muddy clay or high sediment-concentration liquid. In this paper, a fundamental procedure for solving the problem is based on the principle of the rheological consideration.

This paper consists of three chapters. In the first chapter, the creep characteristics of muddy clay are discussed. The deformation of material as muddy clay at any time is expressed generally by the sum of recoverable and unrecoverable parts of the deformation. The behavior of the material is disclosed with the aid of the integral equation of Boltzman. In the second chapter, characteristics of the flow of muddy clay in an open channel are considered. It is concluded that the flows of muddy clay follow the Bingham or pseudoplastic law and that the resistance law of the flows in an open channel is expressed by the logarithmic law with a modified Reynolds number similar to that for Newtonian fluid.

In the third chapter, the authors consider the rheological property of a lower layer of flows with high sediment-concentration near the bed in the flow of liquid with relatively low concentration. Since the velocity profile in this layer deviates from the logarithmic law applying to the region of mainflow, the cross section of flow is considered to be divided into two parts, the upper and the lower which are treated as Newtonian and pseudoplastic flows respectively. It is found that the thickness of the lower layer can be calculated on the basis of the condition that the Richardson number is equal to just unity at the boundary between the upper an lower layers.

An Experimental Study on Sand Waves (1)

By Kazuo Ashida and Yuichiro Tanaka

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 271–280.

Abstract

It is one of the most important problems for hydraulic engineers to solve the mechanism of sand waves. Because sand waves occur almost every time the bed materials are moved by running water so giving various difficult problems. We know the existence of various bed configurations, ripples, dunes, stationary waves, anti-dunes etc.. But we cannot fully explain these complex phenomena at present. There are many problems with regard to sand waves. It is, especially, required to make clear the geometrical property of sand waves, to explain the resistance law in the alluvial streams. In previous works, one has tried to show the form characteristics with H/λ because sand waves have wavy property, where H is the height of sand waves and λ is the wave length. But sand waves have not only regular but also random characteristics in geometrical property. It seems that the characteristics of sand waves are decided by the rate of the regularity and the randomness.

Authors started a series of studies from the standpoint of thinking these phenomena as one of the stochastic process. For the sake of accomplishing these studies, we must measure the variation of the water level and the bed elevation with time continuously, exactly and simply.

As the first step of these studies, authors manufactured an equipment using an ultra-sonic device by the aid of Oki Electric Industry CO., LTD. This equipment can measure the water level and the bed elevation with sufficient accuracy (± 1 mm.). The measured results are given as the digital records.

Authors experimented on the sand waves using this equipment for few cases of the regime of ripples. They found that even regular ripples have two or three periods by spectral-analizing on the measured data at intervals 30 sec. And they discussed the significance of the mean values of the period, wave length, wave height etc. as the characteristic values of the sand waves.

Flow through Curved Open Channels
Part 1. On characteristics of upper layer in fully developed region

By Yoshio MURAMOTO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 2, February 1965, pp. 1–14.

Abstract

This paper presents the theoretical consideration and the experimental verification of the upper layer in a fully developed region of curved flows, as the first stage of an analytical approach to the general curved flow.

The fundamental equations of the upper and the lower layer are derived from the Navier-Stokes equation of motion and the approximate expression of continuity. As for the upper layer unaffected by the shear stress of the side walls, the radial distributions of radial and tangential velocity and the surface profiles of water are determined by the use of the following assumption, " in one cross section of curved flows, the mean depth coincides with the depth at centerline radius"

The effects of the secondary flow on the main, tangential flow are discussed in comparison with a flow as a free vortex. In consequence, it is concluded that the secondary flow has an influence upon the main flow in shifting the higher velocity filaments towards the outer bank and increasing the superelevation of the water surface. The general properties with increase of the relative radius and some calculated examples of tangential velocity and surface profifes are also presented.

Furthermore, on the basis of the experimental results conducted in several kinds of single curved channels with 90° and 180° central angle, the assumption described above, the radial distribution of the main flow and the surface profiles are examined.

Resulting from the present study, it was confirmed that the fully developed region in the curved open channels is restricted to the later portion of the curved section and the experimental data in this region supports the present theory.

Internal Structure of Flow through Curved Open Channels

By Yoshio MURAMOTO and Takayuki INOUE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 415-427.

Abstract

This paper describes the internal structure of curved flow based on the measurements of three dimensional velocity components in two kinds of 180° single curved channels under conditions of subcritical flows.

In order to obtain the velocity components in the three directions, a flow direction instrument with an improved type pitot sphere is designed. The errors in measurement of flow direction due to the veloity difference at two pressure holes of the pitot sphere and the accuracy of the differential manometer used, are previously calculated from the theory of potential flow around a sphere.

Considering the properties of velocity and vorticity components observed, the flow through a curved section, as an idealized model, is divided into three regions, namely, a generated region, a developing region and a fully developed region. The first region has components of a longitudinal and a radial vorticity and is characterized by the generation of a secondary flow which may be described by the simple deformation of a vorticity in the upper straight channel. The second region may be considered as a transitional regime to the final region, and the deformation and the rotation of the vorticity is progressed. The last region is a kind of equillibrium regime and may be analyzed by the three dimensional boundary layer theory, since three dimensional properties of vorticity are confined within the lower layer and the upper layer has only the vertical vorticity component.

The longitudinal distribution of secondary vorticity derived from the Helmholz equation of vorticity and an assumption of a free vortex for main flow was confirmed by the experimental results in the generated region. Further, the radial distribution of tangential velocity in the later portion of the curved section supported the theory of the fully developed curved flow.

On the Characteristics of Open Channel Flow on the Bottom Intake Orifice

By Yoshiaki IWASA and Hiroji NAKAGAWA

Proceedings of the 9th Conference on Hydraulics in Japan,
February, 1965, pp. 31–36.

Abstract

It is a very important problem for hydraulic projects such as diversion or intake works to give exactly a theoretical expression of the mechanism of open channel flow of non-uniform discharge. But this is extremely difficult because various factors included in the fundamental equations, peculiar to non-uniform discharge flow, cannot be represented in dynamic form. To make the role of these factors clear, the characteristics of gradually varied flow of non-uniform discharge were inuestigated by experiments on the bottom intake orifice.

Experiments were conducted in a flume 0.25 m in width, 1 : 200 in bed slope. A bottom intake section consisted of 63 circular orifices, 8 mm in diameter, which were distributed 5 cm apart longitudinally and 2.5 cm transversely. Results of the test are summarized in the following conclusions:

(1) Values of the momentum and energy correction factors obtained from the velocity distributions rapidly increase in the direction of the flow under a subcritical state, while under a supercritical state they remain nearly constant.

(2) When the flow rate released from the orifice is indicated in the form, $q=C_H b\psi\sqrt{2gH}$, the values of the discharge coefficient C_H decrease with the increase of the Froude number of the main flow.

(3) The values of the coefficients which represent the magnitude of the momentum flux lost by the released water vary in a wide range.

(4) A good agreement between the observed and computed water surface profile has been shown, except at the end section of the intake.

As to the transitional characteristics which would appear on the intake, it is verified by using the singular point theory that the nodal point occurs for the bottom intake with circular orifice or transverse slit.

Historical Development and Some Experiences of Energy Dissipator at Multiple-Purpose Projects in Japan

By Yoshiaki IWASA and Hiroji NAKAGAWA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 3, March, 1965, pp. 65-81.

Abstract

The Ministry of Construction of the Japanese Government has completed more than fifty multi-purpose reservoir projects after the World War II. A historical view of the development of water-release equipments and their energy dissipators, and the results of investigation on their performances after completion is described herein.

Investigated are design procedures of outlet and spillway works which have been developed to fit the hydrological and geographical requirements peculiar to the rivers in this country. It is emphasized that to satisfy these requirements it has become a recent trend in outlet design to provide high-pressure large scale conduits, capable of partial opening in operation, or to use large rectangular orifices for moderate operating heads. It is noticed that, as the outlet and spillway have been equipped separately, a definite conception on the release of water for service and emergency operation, respectively, has resulted in a better and more economical design of energy dissipators.

As to the development of energy dissipators, it is indicated by the plots of the relative length of existing jump-type stilling basins that their economical construction has been attained by use of the appurtenances. A few types of energy dissipators which were designed through the model tests to satisfy the requirements are described; A laterally curved basin with a skewed dentated sill, a horizontal basin with a trapezoidal subdam, and water cushion-type energy dissipator are some.

Performances of the existing water-releasing devices at multi-purpose dams were investigated to obtain data for practical information in the design as well as the future maintenance of the works and to verify the model indication with the observed results of the prototype. The results of the invesigation are shown in tabular form and led to the following conclusions:

(1) Operation of the spillway should be conducted to make the released flow symmetric to the center line of the basin, so as not to cause a laterally back current which might draw eroded debris into the basin.

(2) Insufficient apron-length and subdam-height will induce severe erosion in the whole reach of the basin, without exception.

(3) To certify the satisfactory performance of the stilling basin which is commonly used in spillway and outlet works, a model test should be made for a large variety of combinations of outlet and spillway discharge.

Several Features of Hydraulic Jump Formed by Weir with Trapezoidal Section

By Yoshiaki IWASA and Hiroji NAKAGAWA

Transaction of the 11 th Congress of International Association for Hydraulic Research, Leningrad, September, 1965.

Abstract

When the trapezoidal weir is used as a secondary dam there appear the critical states of the jump in which the flow becomes supercritical in the whole reach of the basin and in which the splashing flow begins to form a jump in the basin. These critical states which are called "jump-splash" critical and "splash-jump" critical, respectively, give the information of the limit in the stability of the jump.

In this paper, the flow characteristics under these critical conditions obtained by experimental analysis are described. The analytical results for the free overflow condition are nearly same as those described in Annuals, Disaster Prevention Research Institute, Kyoto University, No. 8, on the subject of "Studies on Forced Hydraulic Jump (1)"

In the case of a weir submerged in jump, the relative location of the jump is determined not only by the Froude number of the entering flow, F_1, and the relative weir height, but by the relative tailwater depth. The general design chart which includes these factors and the drag coefficient of the force exerted by the weir, C_d, is presented on the basis of the momentum analysis. The measurement of the pressure force indicates that C_d decreases with the increase of relative location of the jump and F_1.

At the "jump-splash" critical state, it is seen that C_d decreases proportionally to the increase of F_1. At the "splash-jump" critical state, assuming that the jump is formed at the downstream end of the weir crest and that the pressure distribution on the downstream face of the weir is hydrostatic, the theoretical expression which gives the required tailwater depth to from a jump is deduced from the momentum and continuity equations. Plots of the experimental data verify these theoretical relationships within close limits.

Studies on Forced Hydraulic Jump (1)
—Several Features of Hydraulic Jump Formed by the Secondary Dam with a Trapezoidal Shape—

By Hiroji NAKAGAWA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 235–244.

Abstract

Forced hydraulic jump is defined as a jump which is formed by the stilling basin appurtenances when the jump would be swept out due to insufficient tailwater depth. A secondary dam with a trapezoidal section is widely used as an effective appurtenance of the stilling basin in the flood control projects in Japan. It is a peculiar feature of the jump formed by this type of the basin that the critical state appears, under which the flow becomes supercritical in the whole reach of the basin, and under which the splashing flow begins to form a jump in the basin. The critical conditions stated herein are called "jump-splash" critical and "splash-jump" critical, respectively, and represent the forced jump condition giving the information of the limit in the stability of jump. The hydraulic performances of the secondary dam shown at these critical states, in the cace of a free overflow condition where the tailwater does not influence the flow condition in the basin, are described.

The contents of this paper are as follows; First, the hydraulic performances of all kinds of stilling basin appurtenances are explained by the one-dimensional momentum equation, established between the sections of the beginning and the end of the basin. Second, the experimental investigation conducted in a flume of 5.5 m in length, 0.5 m in width, provided with a 1 : 1 sloping weir, is described. The ratio of the basin length and the surface roller length to the normal jump length at the "jump-splash" critical state take constant values of 0.9 and 0.8, respectively, for any initial Froude number F_1. It is seen that the ratio of the maximum jump depth to the normal jump height increases in proportion to F_1.

Third, the analytical consideration of the weir performance shown in the transition from jump to splash is described. The pressure force is estimated by assuming the curved flow pattern at the control section which appears on the crest of the weir. The ratio of the force exerted by the upstream face of the weir to the hydrostatic pressure force obtained from the pressure and depth measurement varies with a certain tendency against F_1. The height of weir necessary to maintain jump computed by the momentum equation using these force ratio curves has shown a fairly good agreement with the experimental values.

Fourth, the mechanism of the occurrence of a "splash-jump" critical state is discussed. Assuming the critical condition to be attained on the crest and the supercritical condition on the upstream face of the weir, the required weir height to begin to form the roller in the basin is deduced theoretically from the momentum and and energy equations established between sections on the weir. A good agreement between the observed and computed heights is recognized.

Periodic Variations in Amounts of Precipitation in Japan

By Mutsumi KADOYA and Tatsuo KOIKE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 307–315.

Abstract

In planning hydraulic works, it is important to examine the stochastic characteristic, especially the trend of long-time periodic variations contained in the time series of hydrologic amounts. The characteristics have been hitherto studied by some investigators from the view point of mainly climatology, partly engineering. These studies, however, do not seem to be enough from the view point of hydraulic planning.

As the first step of the study, in this paper, the outlines of periodic variations were examined in the time series of annual total and annual maximum of daily amounts of precipitation at 19 gauging stations in Japan. It was found that the variations of $T \geqq 10$ and $T \geqq 19$ in years, which were separated from these series by the helps of peridogram analysis and over lapping moving average have the following characteristics:

For the annual sum: (1) The trends of periodic variations of $T \geqq 19$ are similar to one another, generally and of $T = 45 \sim 60$ are remarkable except Hokkaido. (2) Considering the trends of variations of $10 \leqq T \leqq 18$, the several regions, in which the trends are similar, are classified in Japan.

For the annual maximum: (1) The variations of $T \geqq 19$ seem to be non-significant in the sense of statistics and negligible in the sense of statistics and negligible in the sense of engineering in most of the locations. (2) The trends of the variations of $10 \leqq T \leqq 18$ are not always similar even in one region.

It was concluded from the above results that the long-periodic variations in the hydrologic amounts of short duration are almost negligible from a view point of engineering and seem to be much stochastic, though the one for long duration have similar trends to one another in a region and or generally. The detailed method of application of these results to water works were suspended in this paper, because the several problems to be discussed have remained unsolved.

Direct Measurement of Botom Shear Stresses in Open Channel Flows

By Shōitirō Yokosi and Mutsumi Kadoya

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, March, 1965, pp. 41–51.

Abstract

The most significant resistance in an open channel flow is a bottom friction which is a fundamental parameter of a structure of turbulent boundary layer. A high sensitive device for measuring the shearing stresses on the bottom of an open channel with a method of a direct balance is developed. In this device, a portion of the bottom (15 cm × 6 cm) is arranged to form a floating element separated from the rest of the bottom by a narrow gap and is suspended by four threads like a pendulum. Small streamwise displacement of the floating element is measured by means of a differential transformer acting as a displacement gauge. Features of the device are that a very small shear stress down to 0.01 dyn/cm^2 in magnitude can be easily detected, a sensitivity adjustment can be easily made in a wide range, and a linearity exsists between the shear stress and the displacement of the sensing element.

Some measurements are made in a steel open channel which is 39 m long, 50 cm wide and 20 cm deep. The device is mounted in the midstream section a third from the down stream end of the channel. Estimation of the Kármán's constant is made, determination of which is easily made by simultaneous measurements of the bottom shear and a velosity profile above the bottom. Results show that the Kármán's constant of water flow is approximately 0.40.

The resistance coefficient of a flow with very mild hydraulic gradient is examined. At the experiments of such flow, the resistance coefficient increases extraodinarily compared with that of Blasius as the down stream end of the channel is dammed up. In order to make the above facts clear, more accurate measurements of the boundary shear have been wanted. The results of the measurements give us instructive knowledge to make clear the apparent increase in the resistance coefficient in a dammed up flow.

Statistical behaviour of the fluctuation of the bottom shear stress is examined. Power spectra of the bottom shear fluctuations are computed by digital computer. The obtained spectra show that there exist two regions in which the spectral law of shear is n^3 and n^9 in the low frequency range, where n is the frequency.

Measurement of Spectra of Turbulent Wall Shear in Open Channel Flow

By Shōitiro Yokosi

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 429-437.

Abstract

Turbulent bottom shear can also be expressed as the sum of the time averaged value and the fluctuating component like other turbulent quantities. However, an investigation of the statistical characteristics of turbulent bottom shear has not yet been made. The statistical nature of the fluctuation of the bottom shear can be regarded as a manifestation of the motion of the eddies moving contact with the bottom surface. The flow of a broad open channel contains eddies of various size, from the largest eddies, whose size of the order of the depth of the flow, to the smallest eddies, the turbulent viscosity of which is of the order of the kinematic viscosity of water. Since the fluctuations of the bottom shear are thought to result from the motion of each eddy, they form a band spectrum. An investigation of the spectrum of the bottom shear are useful not only to promote our knowledge on the structure of the bottom shear but also to enrich our experience of the various turbulent phenomena in a turbulent boundary layer.

Power spectra of the bottom shear are measured with the aid of a wall shear meter, which is a device for measuring the bottom shear stresses by means of the method of a direct balance. Reuslts show that the spectrum of the turbulent bottom shear in a lower frequency range consists of two parts where the spectrum seems to be proportional to n^3 and n^9, where n is frequency. Brief considerations about this matter are given under the following assumptions. A variation of the bottom shear, similar to that of velocity, will be related to the motions of eddies of various sizes. Furthermore, it is supposed that the mean bottom shear is in proportion to the square of the mean velocity through a resistance coefficient is also applicable to the relation between the fluctuating bottom shear and the velocity.

Runoff Characteristics of Yamashina River Basin
—Study on Exclusion from Flooding Trouble in the Low-lying Basin of the Lower Reaches of Yamashina River (1)—

By Eiji TOYOKUNI, Mutsumi KADOYA and Gyozo OHASHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 297–306.

Abstract

The hydrological observation has been carried out since 1963 in Yamashina River basin which has the area of 56.1 km², with an aim to make clear the hydraulic behaviour of inundated water in the low-lying district.

As the first approach to the problem, the following study has been carried out. The basin has been divided into some small-basins such as characterized mainly by the bush land with steep slope, the thickly wooded hill, the urban land and the paddy basin, respectively. The runoff characteristics of these basins have been examined in the form of equivalent roughness in the method of runoff analysis by characteristics of the uniform flow, and the results are tabulated in the Table.

These values of equivalent roughness are available to route the runoff from rainfall on the basin varying with land development, may also be applicable for the other basins with similar land surfaces.

Table. Equivalent roughness for each research basin

Research basin	Equivalent roughness ($m^{-1/3}sec$)	Remarks
Developed building land on the Okura hill.	0.05	Terraced building land.
Partly developed building land, near the Okura hill. (Dono river basin)	0.1~0.2	Terraced building land (15% of total area).
Paddy field basin.	1~3	Net of the drainage channel is in the bad state.
Headwater basin of Yamashina river.	0.2~0.4	
Kyuanshoji river basin.	0.6~1.1	Low-lying district (50% of total area) consisting of the paddy field and urban district, and hills.
Anshoji river basin.	0.4~0.8	Mainly wooded hills.
Shinomiya river basin.	0.3~0.5	Wooded hills, terraced farm land and urban land.
Otowa river basin.	0.3~0.5	Wooded hills, terraced farm land and urban land.
Iwaya river basin.	0.2~0.4	Hills having mainly terraced farm land.

Unsteady Flow of Ground Water into Ditch (1)

By Gyōzō Ōhashi

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 327–341.

Abstract

In designing the drainage system, it can be of great importance to know the characteristics of unsteady seepage flow of groundwater into ditches.

The behaviour of the unsteady flow to a system of parallel ditches above a horizontal impervious boundary has been dealt with theoretically and experimentally.

The solution of the nonlinear equation of the flow has been examined after a model of the Boussinesq's approximation proposed for linearizing the equation. In order to verify the property of the solution, experiments under various conditions have been made by a sand tank having 21.6 m long, 1.0 m wide and 1.2 m deep.

There are a few disagreements between the theoretical value and the experimental result, which seem to be the error due to the simplification of the equation. The coefficients of corrections based on the experimental results are examined to compensate the discrepancy of both values. And a formula for determining the spacing of ditches is derived from the corrected solution.

The coefficients contained in the solution are able to be represented as a function of the changes in groundwater height relating to both time and place, and their dimensionless form are presented from the engineering points of view.

Studies on Cnoidal Waves (Second Report)
—On the Wave Velocity and Wave Length—

By Yuichi IWAGAKI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 343-351.

Abstract

In the first report, of which the abstract was described in the Bulletin, Vol. 14, Part 4, March 1965, the graphs and the method to compute the wave profile from a given wave steepness and water depth to wave height ratio were presented based on the cnoidal wave theory developed by Laitone in 1961.

This paper provides the graphs to find easily the wave velocity, wave length and value of the complete elliptic integral of the first kind from a given wave period and still water depth and wave height for practical use based on Laitone's cnoidal wave theory.

In addition, comparisons of the wave velocity and wave length are made between the first and second approximations of Laitone's solution and between Stokes waves of the third order approximation, Airy waves, cnoidal waves of the second approximation and the solitary wave. As a result, it is found that (1) the wave velocity of cnoidal waves of the second approximation is at most about 4% smaller than that of the first approximation when $h/H=2$, and about 1% smaller when $h/H=5$ except when the value of the complete elliptic integral of the first kind is very small, and (2) for the wave velocity and wave length the cnoidal wave theory cannot be applied in the range $T\sqrt{g/h}<5.5$ and Airy's small amplitude theory can be applied in the range $5.5\lesssim T\sqrt{g/h}\lesssim 20$ independently of h/H if an error of about 5% is allowed (h: the still water depth, H: the wave height, T: the wave period and g: gravity acceleration).

On the Trasformation of Ocean Wave Spectra in Shallow Water and the Estimation of the Bottom Friction Factor

By Yuichi IWAGAKI and Tadao KAKINUMAWA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 379-396.

Abstract

One of the most important problems in coastal engineering is the estimation of the transformation of waves as they approach the shore through shallow water.

In this paper, from the damping of the significant wave heights and the transformation of the wave spectra observed at Izumisano Coast and Hiezu Coast, the loss of wave energy due to bottom friction is investigated quantitatively and the bottom friction factors of these coasts are estimated. In estimating the bottom friction factor by the wave spectrum method, it is assumed conveniently that each component wave propagates independently.

The values of bottom friction factors at Izumisano Coast estimated are 0.14 and 0.55 by the significant wave method, and 0.013~0.054 and 0.25~0.55 by the wave spectrum method. At Hiezu Coast, the values estimated are 0.027~0.16 and 0.040~0.44 respectively. It should be noted that these values are much greater than 0.01 which was given by Bretschneider to be generally used in forecasting shallow water ocean waves.

It is found that the longer the significant wave period or the higher the value of the accompanying wave Reynolds number is, the smaller the value of bottom friction factor estimated by the significant wave method is, and that these values are about ten~seventy times the theoretical values obtained in the laminar wave boundary layer theory. In addition, the values estimated by the wave spectrum method seem to have the same tendency as those by the significant wave method except Data No. I-1, and are about ten~one hundred and twenty times the theoretical.

On the Bottom Friction Factors of Some Japanese Coasts

By Yuichi IWAGAKI, Tadao KAKINUMA and Hiroshi MIYAI

Proc. of 12 th Conf. on Coastal Eng. in Japan, Nov., 1965, pp. 35–40.

Abstract

The relationship between the bottom friction factors of coasts and wave characteristics or their bottom conditions has to be well known in order to forecast shallow water ocean waves.

In this paper, from the damping of the significant wave heights and the transformation of the wave spectra observed at Nishikinohama Coast, the loss of wave energy due to bottom friction is investigated quantitatively and the bottom friction factors of this coast are estimated and the relationship between the bottom friction factor and the wave Reynolds number is found for relatively small waves.

The values of bottom friction factors at Nishikinohama Coast estimated are 0.28 and 0.37 by the significant wave method, and 0.063～4.00 by the wave spectrum method when $h_N/L_N<0.2$ (h_N: the water depth at the onshore-side station, L_N: the length of spectral component waves onshore-side or significant waves onshore-side).

Using the values of bottom friction factors of this coast and some other Japanese coasts, it is found that the higher the value of the wave Reynolds number is, the smaller the value of the bottom friction factor estimated by the significant wave method is, and that these values are from about seventy times to about ten～seventy times the theoretical values obtained in the laminar wave boundary theory in the range from 10^5 to 2×10^6 of the values of the wave Reynolds number when $h_N/L_N<0.2$. In addition, the values estimated by the wave spectrum method seem to have the same tendency as those by the significant wave method, and are from about fourty～two hundred times to twenty～one hundred times the theoretical in the range from 3×10^4 to 2×10^6.

Some Experiments on the Influence of Size Frequency Distributions of Sediments on Their Suspension

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Yoichiro YANO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 353-362.

Abstract

Some experiments on the influence of size frequency distributions of sediments on their suspension in water were carried out by using a small water tank having several oscillating holed plates such as used by H. Rouse in 1939. The purpose of the experiments is to clarify whether the method of superposition such as Einstein's one, to estimate the concentration of graded sediments in suspension, is applicable or not in a turbulence field.

Graded sediments of four kinds of size frequency distributions which are plastic powder with the specific gravity of 1.273, the same medium diameter of 0.015 cm and the standard deviations of 1.21, 1.47, 1.99 and 2.56 respectively, and uniform sediments of the medium diameter of 0.015 cm were used in the experiment. Some experiments for uniform sediments to verify the uniformity of the turbulence field in the tank and the uniquness of the suspension phenomena were performed with the aid of the basic equation of sediment suspension. The distributions of sediment concentrations of graded sediment in suspension and size frequency distributions of suspended loads were measured in various cases.

Based on the results of the experiment, some comparisons were made between the calculated distributions of sediment concentrations and the experimental results, and variations of coefficients of eddy viscosity estimated from the basic equation of sediment suspension using the experimental results, characteristics of size frequency distributions of suspended sediments and variations of concentrations of sediment at a reference level with standard deviations of sediments were discussed.

It is concluded from the above considerations that the method of superposition is not applicable in turbulence fields; therefore, the mechanics of suspension of graded sediments should be established in connection with turbulence spectra although some essential facts for this are explained on the basis of the experimental results.

Studies on the Local Scour from Flows Downstream of an Outlet (1)

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Masataka IMAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 363–377.

Abstract

In order to prevent scouring resulting from flows downstream of an outlet, it is necessary to establish the mechanics of the scour. A series of experimental investigations on the local scour from wall jets issuing from a submerged outlet was performed by using small and large experimental water tanks and sediments of eight kinds of sizes.

As a first report, general considerations on the nature of scour are considered based on the experimental results. It is concluded from the considerations that profiles of scour holes can be expressed in the dimensionless form such as done by Laursen and that variations of the maximum depth of scour with time can be represented in a dimensionless form connected with the characteristics of wall jets with the aid of the dimension analysis and similitude in the phenomena of scour is considered to be expressed by the above dimensionless paramters on the basis of the results in both small and large experimental water tanks. However, such considerations cannot be applied in the case when there exists a periodic phenomenon of scour and the tail water depth is very shallow.

In addition, a theoretical approach to disclose the mechanism of the scour for an initial step of scour is presented by applying both the characteristics of wall jets issuing from an outlet and basic equation of scour. It is found from the comparison between the theoretical relationship and the results of the experiment for an initial step of scour that the depth of scour increases linearly with time and the phenomenon of the scour can be disclosed by the theoretical approach. For a developed step of scour, since the phenomenon will depend upon the growth of rollers developing in a scour hole, the mechanism of the scour is discussed with the aid of the characteristics of such rollers.

Basic Studies on the Wave Damping Due to Bottom Friction (Third Report)
—On the influence of convective terms in laminar boundary layer equations—

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Huoxing CHEN

Proc. 12th Conf. on Coastal Eng. in Japan, Nov., 1965, pp. 41–49.

Abstract

The phenomenon of wave damping due to bottom friction is of interest and also of practical significance in determining design waves for coastal structures in shallow water. This paper presents a part of the results of the basic studies on wave damping due to bottom friction which have been performed for several years at the Ujigawa Hydraulic Laboratory. The investigation on damping characteristics of oscillatory waves was made by means of the direct measurement of instantaneous shearing stresses exerted on a smooth bottom due to waves and by the observations of wave amplitude attenuation with distance. On the other hand, in a theoretical approach the effect of convective terms involved in the basic equations of laminar boundary layers developing both on the bottom and on the side walls of a wave tank resulting from wave motion, is considered on the basis of an approximate solution of the equations which was derived by the authors with the aid of the perturbation method. Based on the above solution a theory of the wave damping due to bottom friction in the case of laminar boundary layer is established after estimating the effect of convective terms on wave energy dissipation in laminar boundary layers. The theoretical results are compared with the results of the experiments and the linearized theory on the laminar boundary layer growth and wave damping.

With regard to the shearing stresses on a bottom due to wave motion, it was found that the effect of convective terms is negligible within the range of the experiments; therefore, the result of the linearized theory agrees well with the experimental one. With regard to the wave energy dissipation in laminar boundary layers it was concluded that the effect of convective terms on the rate of wave energy dissipation in the boundary layer on the bottom is negligible, but that on the side walls it is as much as 20% of the value derived from the linearized theory. On the other hand, it was clarified from the experiment on wave damping that the moduli of wave damping by the experiments are approximately 40% larger than those derived from the linearized theory, while, when the experimental results are corrected by the author's theory, they decrease as much as 10% and approach nearer to the theoretical relationship than they do the linearized theory.

Basic Studies on the Wave Damping Due to Bottom Friction

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Masayuki SAKAI

Coastal Engineering in Japan, Vol. VIII, Dec., 1965, pp. 37–49.

Abstract

In order to disclose the mechanism of wave damping due to bottom friction, the authors made a device using a moment meter to measure the bottom shearing stress resulting from wave motion and measured directly the bottom shearing stresses due to oscillatory waves. In addition, an experiment on the wave damping in a wave tank was performed and the characteristics of wave damping coefficients and moduli of wave damping were investigated. The experimental results were compared with the theoretical ones based on the linearized boundary layer theory.

This paper is an English translation of the paper published in Proc. 11 th Conf. on Coastal Eng. in Japan, Nov., 1964, pp. 62–68, of which the abstract was described in the Bulletin, Vol. 14, Part 4, March, 1965.

Studies on the Effect of Wind on Wave Overtopping on Seawalls (First Report)

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Masao INOUE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 397–406.

Abstract

In designing seawalls and seadikes, it is very important to estimate the quantity of wave overtopping them as exactly as possible. The estimation, however, is difficult because of the complicated phenomena of wave overtopping, and especially the effect of wind on wave overtopping is entirely unknown.

From this view point, the authors have begun a study to clear the effect of wind on wave overtopping quantitatively. This paper is the first report of these studies. First, the quantity of wave overtopping on the vertical seawall set on the model beach of 1 on 15 slope was measured for the incident wave steepnesses of 0.01, 0.02 and 0.03 without wind.

Second, experiments of wave overtopping on the vertical seawall were carried out to find directly the effect of wind on wave overtopping by using a high-speed wind-wave tunnel, which is 0.8 m wide, 2.3 m to 4.0 m high and 40 m long, having a blower of 100 HP and a wave generator of submerged piston type with a motor of 10 HP. The ratio of the water depth at the toe of a seawall to the wave length were changed in five cases in these experiments. The experimental results were plotted in the form of the dimensionless quantity of wave overtopping against the Froude number expressed by the wind velocity and the wave height with a parameter of the relative crest height of the seawall to find the effect of wind on wave overtopping. From these figures, it was found that the effect of wind on the quantity of wave overtopping varies remarkably with the ratio of the water depth at the toe of a seawall to the wave length.

Studies on Wave Overtopping on Seawalls and Seadikes by Using a Wind-Wave Tunnel (2)

By Yuichi IWAGAKI, Masao INOUE and Koichi OHORI

Proc. 12th Conf. on Coastal Eng. in Japan, Nov., 1965, pp. 186–192.

Abstract

This paper is the second report of the study to clarify quantitatively the effect of wind on the quantity of wave overtopping on seawalls and seadikes. In the paper, the experimental results of wave overtopping on the vertical seawall set on a beach of 1 on 15 slope in a high-speed wind-wave tunnel are described for wave steepnesses of 0.01 and 0.02. In the experiments, five cases of the ratios of the water depth at the toe of the seawall to the wave length are treated for each wave steepness.

The experimental results produce the following conclusions:

(1) When incident waves do not break in front of the seawall, the quantity of wave overtopping begins to increase suddenly with increase in the Froude number $V/\sqrt{gH_0}$ expressed by wind velocity V and deep water wave height H_0, after its value reaches about 6 to 7 for the wave steepness of 0.01 or 3 to 5 for the waves steepness of 0.02. Moreover, the increasing segment of the quantity of wave overtopping because of wind is considerable compared with that in other cases.

(2) When incident waves break just in front of the seawall, the quantity of wave overtopping shows a complicated change with increase in the wind velocity for the wave steepness of 0.01, and on the other hand, it becomes approximately constant over low wind velocities for the wave steepness of 0.02.

(3) When incident waves break before they reach the seawall, the effect of wind on wave overtopping is not remarkable; namely, the increasing segment of quantity of wave overtopping because of wind is small even at high wind velocities.

On the Resonance Effect in a Storm Surge (Part I)

By Hikoji YAMADA, Jun-ichi OKABE[1] and Masako KUMAZAWA[2]

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 1, No. 89, Sept., 1965.

Abstract

More or less varied estimations seem to be asserted concerning the sudden growth of high water as observed when a pressure disturbance passes through the resonance point defined with respect to the depth of water. Computations are performed in this paper with a view to studying the theoretical phase of the problem. Confining ourselves to the case of one-dimensional expanse of water surface, the equations of motion are reduced to the forms of the so-called 'shallow water theory'. In this simplification, the non-linear terms of the equations are preserved, while, on the other hand, effects of viscosity are altogether left out of consideration, because, as pointed out in the second report, they possibly do not modify the situation drastically. In the first place, the steady swell accompanying a disturbance of invariable intensity which advances with a constant velocity upon the surface of water of a uniform depth is formulated analytically without difficulty, and when the state is of near resonance results of the linear approximation generally used in the past are shown to need large corrections. In the next place, the swell of water taking place when a disturbance, climbing up an inclined bed and approaching a shore, goes through the resonance point is calculated numerically by the aid of an electronic computer. It is found that the smaller the slope of the bottom the higher is the tidal level, and that even usually experienced inclination is still sufficient to produce an ascent of level up to several tens percent. It is concluded, therefore, that the resonance phenomenon could not possibly be neglected, except when it is canceled out by chance owing to some three-dimensional influences.

1) Professor, Research Institute for Applied Mechanics, Kyushu University.
2) Former Research Assistant, Faculty of Engineering, Kyoto University.

On the Resonance Effect in a Storm Surge (Part II)

By Hikoji YAMADA and Jun-ichi OKABE[1)]

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 2, No. 94, Nov. 1965.

Abstract

In Part II of this paper it is shown that, provided some errors be overlooked, effects of meteorological factors can be expressed solely in terms of an atmospheric pressure gradient when a storm surge computation is performed. It is also noted at the same time that the theoretical equations derived here, taking account of eddy viscosity, coincide approximately with the empirical formulae which have come into general use very recently. By means of our computational scheme, the influence of eddy viscosity upon the resonant intensification of waves is studied, and it is concluded, after some investigations and calculations, that generally it is small and in some cases small enough to be safely ignored. Next, the disturbance which has been assumed ever since Part I is too small in its spatial extent to stand for a larger example such as a typhoon. Therefore a resonant high water caused by a depression whose dimension is large compared with the linear scale of a sloping bottom is computed under similar conditions, but no sensible modification is observed provided the present fundamental assumptions are employed. Finally, since it is formidable in a practical computation of a storm surge to renew meteorological data at every step of the calculation, intermittent supply of the data is performed tentatively. With a view to obtaining a general idea of the situation, the high water treated in our problem is computed again by furnishing data at intervals of certain steps. The fact that no marked difference results gives us not only an understanding of the significance of resonance phenomenon itself but also a suggestion that sufficient reliability may be obtained unless too long an interval is chosen.

1) Professor, Research Institute for Applied Mechanics, Kyushu University.

On Some Characteristics of Tides at Eastern Harima Coast

By Haruo HIGUCHI and Shigehisa NAKAMURA

Proceedings of 2nd Conference of Disaster Science, 1965, pp. 39–42.

Abstract

The authors tried to obtain the fundamental data for prevention of erosion at Eastern Harima Coast. They carried out a tidal observation for this purpose near the spring tide in February, 1965. The data of the tidal currents were obtained along a line of 1 km in length perpendicular to the coastal line. (1) Horizontal profiles along the line, (2) vertical profiles at the stations on the line, and (3) time change of vertical profiles at a station 0.2 km off, where the mean water depth is 4.3 m, were investigated. Although the currents mainly consisted of tidal currents, maximum velocities of which were about 50 cm/sec, 70 cm/sec and 1 m/sec at the stations of 100 m, 300 m and 600 m off the coast respectively, it was found that there were some components of current associated with the seiche in Harima-Nada.

Bottom frictions and eddy viscosities were derived from the data of tidal observations. To calculate the bottom friction, vertical velocity profiles of tidal currents near the sea beds were assumed to be logarithmic and the data of currents at 1 m above the sea bed were used. Maximum values of bottom frictions were 30 and 100 dyne/cm^2 at 200 and 800 m off respectively. Coefficients of bottom frictions were 2 to 30×10^{-3} (5×10^{-3} in average), which were calculated with consideration to the size of sediment. Critical tractive forces were derived from averaged sizes of sediments and compared with bottom friction forces calculated. As a result, it was clarified that the bottom sediment is scarcely transported by only the tidal current. Coefficients of vertical eddy viscosity were also calculated. After that, it was found that the coefficients vary with time but it was not clealy found whether the period of variation of the coefficients corresponds to the tidal period. Time average of the coeficients was about 270 c. g. s. and the components of it were almost the same, 100 c. g. s., for the periods of 120, 60, 40, 30, 24 and 20 min.

Some Characteristics of Tides at Nagoya Harbor and near Akashi River

By Haruo HIGUCHI and Shigehisa NAKAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 439–458.

Abstract

This study has been carried out to obtain some fundamental data of the tidal currents and the related phenomena at Nagoya Harbor and near Akashi River. Bottom frictions and eddy viscosities are derived from the data of tidal observations in these regions. Tidal currents at the openings of breakwater in Nagoya Harbor have been observed in spring tide from January to February, 1964, by the Ministry of Transportation. To calculate the bottom friction, the vertical velocity profile of tidal current near the sea bed is assumed to be logarithmic and the velocity at 1 m above the sea bed is used. The maximum value of the bottom friction is 4.2 dyne/cm^2. The results show that the bottom friction increases with increase in the velocity. A trend is found that the bottom friction decreases with increase in the water depth. The friction coefficient of the sea bed is about 2×10^{-3} in average for the smooth bed which varies with time or with current velocity within the range of 1.5 to 2.2×10^{-3}. The coefficients of vertical eddy viscosity in the cross sections of the two openings are also obtained, areal means of which are 100 to 800 c. g. s. and seem to vary with the tidal phase in a complex relation.

Tidal observations are also carried out by the authors in the region near Akashi River in April, 1964. Vertical and horizontal profiles of tidal currents are obtained. The bottom friction is 0.27 to 24.5 dyne/cm^2 (7 dyne/cm^2 in average). Vertical eddy viscosity is 100 to 800 c. g. s., and horizontal eddy viscosity is 5×10^3 to 10^5 c. g. s.. In the river mouth, the concept of tidal prism is applied to find out the tidal exchange of water. Tidal flows across the mouth of Akashi River are 2.2 m^3/s and 0.2 or 0.4 m^3/s for tidal range of 1.50 m and 0.3 or 0.36 m, respectively.

On Wave Observations at Hiezu Coast

By Haruo HIGUCHI and Tadao KAKINUMA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 459–478.

Abstract

Forecasting shallow water ocean waves is one of the most important problems in coastal engineering. Nevertheless, among the characteristics of shallow water ocean waves, we know little about the wave height reduction due to bottom friction.

To make clear the transformation of shallow water ocean waves, wave observations were made at Hiezu Coast in 1963.

This paper presents the facilities and equipment used, the methods of wave observation, and the results of them analyzed by both the significant wave method and the wave spectrum method.

Three buoys were set along the direction of waves at water depths of 11.8 m, 9.4 m, and 3.4 m, respectively, and the three buoys in wave motion were photographed simultaneously for about ten~fifteen minutes by using two 16 mm cine-cameras with a 400 mm and a 1000 mm telephoto lens. Each buoy is made by connecting four cylinders of 60 cm in diameter and 45 cm in length with angle-iron and has an iron flag of 100×100 cm, which is used as the measure for reading.

Ten wave data could be obtained at the corresponding two or three stations offshoreside and onshoreside. From these data are obtained the transformations of ocean wave spectra in shallow water which are very important in clarifying the energy transmission in shallow water.

In addition, it is found that the ratios of various mean heights of shallow water waves estimated are somewhat smaller than the theoretical values obtained by Longuet-Higgins (1952).

A Study on Photoelectric Current Meters

By Shigehisa NAKAMURA

Bulletin of Disaster Prevention Research Institute, Kyoto University,
Vol. 15, No. 90, Oct., 1965, pp. 63-70.

Abstract

Precise measurement of current velocity has been developed recently, especially for weak current velocity. This paper deals with a current meter for coastal flow, using smoke of Tellurium and a photoelectric system. The model of the current meter devised at first is named I-0 type. The current meter has some attachments such as a vane and a source of smoke to be used as the tracer. At first the axis of the pipe is set paralled to the current direction, and a smoke of metallic Tellurium is ejected as the tracer. The mechanism to issue the smoke is such that when a lump of metallic Tellurium is used as a kathode in saline water which is electrically conductive, powder of purified Tellurium is produced from the surface of the lump just like black smoke. To detect current velocity by the smoke in the pipe, two phototransistors are used.

The relation between the current velocities in the field and in the pipe is studied not only experimentally but also theoretically. The relation is written as

$$\left(\frac{u}{u_t}\right)^2=\frac{1}{2}\left(1+\frac{64L/d}{R_e}\right) \text{ and } \frac{\rho u_t d}{\mu}=R_e$$

where u and u_t are the current velocities in the field and in the pipe respectively, and L and d are the length and inside diameter of a straight circular pipe respectively. Considering the condition of the flume and the field, the length and the inside diameter are decided to be 35 cm and 2.0 cm respetivel.

Then the photoelectric current meter is improved and refined (I-R type). And another most simplified one is planned and constructed (N type). On the other hand, an application of phototransistor is introduced in a measuring unit of current direction. A trial to use the current meters were carried out. From this trial and experience, some limitting conditions in the practical application of the photoelectric current meter in the field were found, that is to say: (1) Calm of the sea condition, (2) Current velocity below 20 cm/sec, and (3) Station fixed to the ground etc.

Salt Balance in Kojima Lake (Part 3) Diffusion Phenomena in Lake Water and Bottom Mud: Supplement; Salinity decrease in Nakanoume after heavy rainfall

By Setsuo OKUDA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 525-534.

Abstract

The salinity distribution in Kojima lake is determined by fresh water inflow from rivers and salt supply originating from sea water and underground water.

In order to estimate the salt supply, field surveys were carried out on the diffusion process of salt in the lake water and bottom mud.

The diffusion process in lake water was investigated by observation of horizontal and vertical spread of dye (uranine) poured from a boat.

Off the sluices, where remarkable density stratification was found, the diffusion process is not isotropic and the ratio of horizontal and vertical diffusion coefficients is about 10^4 in the case of wind velocity 2.5 m/sec, and then under normal conditions the salt transported from lower sea water to upper fresh water can not affect horizontal distribution of salinity in the surface layer of the lake.

The vertical diffusion process in the bottom mud layer was investigated by two methods, (i) observation of diffusion of dye (uranine) in a steel pipe, (4 cm dia, 50 cm length), which was buried in the bottom mud with open top. (ii) observation of vertical salinity distribution in bottom mud to the depth of 200 cm from the muddy bed surface.

The result obtained from dye diffusion in the steel pipe gives very small diffusion coefficicient (10^{-5} cm^2/sec), which shows that a molecular diffusion is dominant in the pipe and does not express a natural state in the mud layer because of stopping ground water movement by the pipe wall.

The distribution of salinity in the ground water through the mud layer observed after 8 years from the exchange of sea water for river water in Kojima lake shows that the dilution effects of fresh water reaches the depth of 2 m from bottom surface and the mean upward transport rate of Cl^- is equal to 4×10^{-4} gr/cm^2 day and has an effect on salinity distribution even at the present stage.

In supplement, an extraordinary decrease of salinity and its stable continuance in Nakano Umi caused by a heavy rain were shown, for an example of stable density stratification in a closed lake with a narrow mouth.

Exploratory Study of a Photo-Electric Sediment Meter and its Applications to Deposits Survey in Amagase Reservoir (Preliminary Report)

By Seiichi KANARI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, 1965, pp.555–565.

Abstract

This paper describes a preliminary model of photo-electric sediment meter capable of determining the thickness of deposited sediment in lake or reservoir, and of transmitting the data electrically through the cable to the shore.

The principle of measurement is that; the probe consits of a series of lamps and a series of 20 pieces of photoelectric cells (6×2.2 mm) in parallel connection. These cells are mounted on a vertical pole which is fixed on the base plate (20×25 cm), and the lamps are set so that the light beams strike perpendicularly in each surface of the cells. As the vertically arranged cells are covered by sediment, the output current of cells (I_D) decreases approximately according to the following empirical formula,

$$I_D = I_0 \cdot (1 - Kp) e^{-\alpha_D x_0}$$

where P is the thickness of sediment on the base plate, x_0 is the distance between the light source and the surface of the cells, α_D is the apparent attenuation coefficient of light between them, K and I_0 are the coefficient dependent on the characteristics of the circuit. In this model, I_0, K and x_0 are known, and α_D is measured by an additional photo-electric cell, therefore we can determine the thickness of deposited sediment from the electrical measurements of I_D and α_D.

From the results of test, it was found that the accuracy of the instrument was about 10 per cent of the working range of 4.8 cm. The results of preliminary survey were shown together with the additional hydrological conditions in Amagase reservoir (Uji City, Kyoto Prefecture).

Exploratory Study of Sand Jet

By Yoshiaki FUKUO

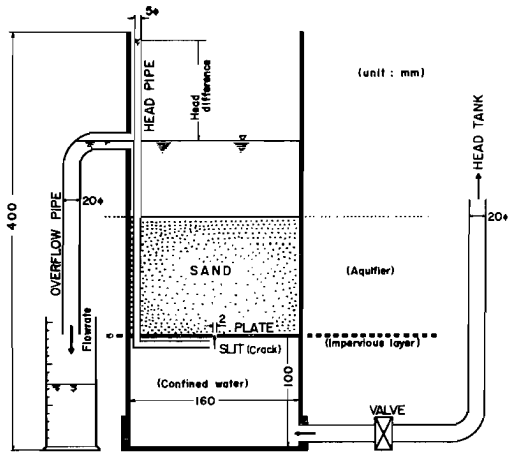
Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 535-541.

Abstract

The fluidization of soil particles is a very important phenomenon as the basic process of quicksand in alluvial plane and piping on mountain slope which are closely related with the geomorphological features.

In the Niigata Earthquake, spouts of ground water and sand were seen here and there in the city and it is said that the damage was magnified heavily by quicksand in the fluvial sand plane.

Considering the spouts observed at damaged districts, the author attempted model experiments of sand jets and made up an apparatus for spouting the sand grains. Its schema was shown in Figure. In this apparatus, confined water was spouted upward from the slit (corresponds to the crack born in impervious layer) and sand jet was generated in sand layer (corresponds to the fluvial sand plane). Various conditions of sand jets in model experiments were recorded by 8 mm cine-films. From the result of experiments, it was suggested that a nondimensional measure of sand jet b/T (b: jet width at the surface of sand layer, T: thickness of sand layer) might be proportional to the reduced seepage rate per unit head difference $Q/\kappa H$ (Q: seepage flowrate, κ: permeability of sand medium, H: head difference between the surface and bottom of sand layer).



Figure; Sketch of apparatus for spouting the sand grains

An Experimental Study on Slope Failure — Preliminary Report —

By Kazuo Okunishi

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 543–553.

Abstract

Model experiments on the slope failure conditions were intended especially in respect to hydrological factors. The experimental equipment prepared consisted of soil flume (5 m long, 0.5 m wide, and 0.5 m deep), rainfall simulator, and head tanks for simulating ground water flow. The soil flume has two water tanks for the supply or the drainage of ground water flow at both ends, and four pluggs to lead to the manometers for ground water head. The inclination of the soil flume can be changed from 0° to 35° continuously by heaving one side of the flume. Weathered granite (coarse sand) was packed in the flume as the sample soil.

Moisture meters, piezometers, pore pressure meters, manometers, and earth pressure meters were used to investigate the hydrological and mechanical conditions of the slope in the flume.

At first, experiments on the water balance of the slope were carried out, applying rainfall and ground water flow with various strength and changing the inclination of the soil flume. In this experiment the measured values about the elements of the water balance were in good agreement with the values given by theoretical calculation.

In order to investigate the failure conditions, the piping of ground water at the upper end of the slope was brought about, which caused heavy superficial erosion of the slope. Another attempt of causing failure phenomena such as the supply of heavy rain and the increase of the inclination of the soil flume was not successful because the shearing strength of the sample soil was too great. In these cases the change of the stress distribution observed was by far less than expected. From this fact it is seen that in sandy soils the variation of the earth pressure distribution can not be measured satisfactorily because of the arching effect prevailing in sandy soils when such a small soil flume is employed.

Triaxial Oscillating Compression Test of Sand

By Sakuro MURAYAMA and Norio YAGI

Proceedings of the 10 th Symposium of Japanese Association of Soil Mechanics and Foundation Engineering, November, 1965.

Abstract

In order to investigate dynamic properties of soil a triaxial oscillating compression testing equipment was newly devised. In this equipment, the ambient pressure (σ_3) and the axial one (σ_1) can be controlled so as to oscillate in any same frequency and in each optional amplitude and phase. Therefore, such stress condition that the mean principal stress σ_m is kept constant while the deviatoric stress ($\sigma_1-\sigma_3$) is oscillated and the contrary condition to the above stated can be produced with this equipment.

This is a report on the dynamic character of sand obtained by this equipment following two cases of stress condition.

(1) After a sand specimen was compressed statically under a certain uniform ambient pressure of σ_3, the ambient oscillating pressure of $(\sigma_3+(1/2)\,a_p\cdot\sin\omega t)$ was applied on it. Where a_p: pressure amplitude, f: frequency ($f=\omega/2\pi$). Under such dynamic stress condition compressive strength (S_d) of the specimen was measured by increasing the axial stress σ_1. The results of the tests are as follows. As far as the frequency was kept constant, the ratio of S_d/S_s (S_s: compressive strength under statical ambient pressure of σ_3) decreased almost in direct proportion to a_p to the intensity of σ_3.

The compressive strength under a constant a_p was influenced by the frequency f of the applied stress and it became minimum when f was nearly equal to 900 c.p.m. Generally the compressive strength $(\sigma_1-\sigma_3)_f$ can be analysed by applying the following equation proposed by Bishop.

$$(\sigma_1-\sigma_3)_f=\frac{dW_f}{d\varepsilon_1}-\sigma_3\frac{d(\Delta V/V)}{d\varepsilon_1}$$

where ε_1 are axial strain, $dW_f/d\varepsilon_1$, and $\sigma_3\cdot d\,(\Delta V/V)\,/d\varepsilon_1$ are compressive strengths contributed by the friction between sand grains and the dilatancy respectively. According to such analysis, the contribution of the dilatancy to the compressive strength is less effective than that of the friction and the later is independent of the stress frequency f.

(2) The compressive strength under a constant σ_m (σ_m: mean principal stress on a specimen) and an oscillating deviatoric stress was investigated. In this test similar relations as above stated were obtained. But in this case, on the contrary to test-(1), the contribution of the dilatancy to the compressive strength is less effective than that of the friction between sand grains.

Swelling of Mudstone or Claystone due to Sucking of Water

By Sakuro MURAYAMA and Norio YAGI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965.

Abstract

Sometimes a newly cut slope or tunnel wall fails due to swelling of mudstone by sucking of water. In this paper, various mechanisms which cause such failure are investigated and clasiffied into the following 3 main cases.

(1) Deviatoric stress can be generated in the mudstone due to the unisotropical expansion caused by sucking of water. In order to examine the character above stated, sample of mudstone obtained from deluvial layer situated below about 180 m from the surface of Osaka City were tested. On these tests, it was shown that the swelling strain perpendicular to bedding was larger than that parallel to the bedding. If the stress on mudstone is decreased under nearly confined state, stress generated in the stone becomes unisotropical. If the deviatoric stress thus generated reaches the strength of the stone, failure takes place in the stone.

These strain or stress due to swelling increase with time and the rate of increase can be estimated by applying the expansion coefficient of rock. Moreover, capability of the sucking of the mudstone was measured by a suction-measureing device.

(2) Failure of structure of the rock can be caused by the local unequal expansion of the containing mineral and the fine seam of different material. To observe such phenomena occured in the rock when the rock sucks water, distribution of local expansive deformation will be measured by the microscope.

(3) Failure of the stone can occur by ununiform swelling due to the unequal distribution of sucked water.

Influence of the Variation of the Intermediate Principal Stress on the Mechanical Properties of Normally Consolidated Clays

By Toru SHIBATA and Daizoo KARUBE

Proceedings of the Sixth International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, September 1965, pp. 359-363.

Abstract

For reasons of simplicity, the practical routine determination of the shear strength of soils in the triaxial apparatus is made under a state of stress with radial or cylindrical symmetry. In nature, however, the soil is stressed under plane strain or under other deformation conditions giving a stress distribution with unequal stresses. Information on the stress-strain and strength behaviour under such states of stress is scarce, and comparisons between standard triaxial test results and those obtained on tests with varying states of stress are much needed.

In this paper, an investigation to compare the behaviour of normally consolidated, remoulded sample of Osaka alluvial clay under standard triaxial and other stress conditions is reported. For this purpose, a triaxial cell was adopted to hold prismatic specimens to whose faces stresses could be applied in such a way as to vary at will the relation between σ_1, σ_2 and σ_3. Undrained tests with pore-pressure measurements were performed after the clay had been consolidated under an equal all-round pressure varying from 0.5 to 3.0 kg/sq.cm.

Findings show that anisotropic stressing does not essentially influence the effective angle of internal friction ϕ'. There is only a small increase which does not seem to be significant for practical purposes. It does significantly influence the stressstrain relation and the pore-pressure development during shear. As has already been shown by others, strains decrease with anisotropy, this decrease being proportional to the difference between the two minor principal stresses.

Pore-pressure development is shown to be only a function of the mean pressure and of the octahedral shear, multiplied by the ratio of the coefficient of compressibility and of the coefficient of dilatancy, irrespective of the relative value of the intermediate stress and of the water content at the start of shearing. Below a certain ratio of octahedral shear stress to mean normal stress, the pore-pressure becomes simply a function of the mean normal stress and is independent of the octahedral shear stress.

Stress-Strain Relationship of Normally Consolidated Clay

By Toru SHIBATA and Daizoo KARUBE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965. pp. 515–523.

Abstract

A fundamental study of the stress-strain pattern of clays is of engineering interst when related to the solution or the understanding of deformation problems or the behaviour in shear failure of clayey ground. Such both are very important matters, the analysis of tests is generally accompanied by a qualitative description or a record of the stress-strain behaviour.

This paper deals with the analysis of a relation between stress and strain of the normally consolidated remoulded clay in undrained triaxial tests. For this purpose, both compression and extension tests were made under stress-controlled and strain-controlled conditions with pore pressure measurements. In the case of strain-controlled tests, the loadings were arranged so that (i) radial stress, (ii) axial stress or (iii) mean principal stress might be maintained constant throughout the tests. The stress-relaxation tests on the identical clay samples were also made to compare with the compression and extension tests.

Findings show that the strengths in terms of the effective stresses measured in these three types of test (compression, extension and stress-relaxation tests) are plotted on the same Mohr-Coulomb failure envelope, and that almost the same values of the peak axial strains are obtained from different types of test.

Pore-pressure induced by the negative dilatent characteristics of normally consolidated clay in the strain-controlled compression and extension tests are shown to be only a function of the magnitude of the oxtahedral shear stress, irrespective of the direction of that shear stress. On the other hand, the pore-pressures developed in both stress-controlled compression and stress-relaxation tests are shown to be simply a fuction of the axial strain and of the magnitude of consolidation pressure. In the axially extension test, however, the pore-pressure is significantly affected by the duration of shear testing. Although it has not been confirmed, the cause of such a time dependent pore-pressure development in the extension test is believed to be a shear restraint at the end platens.

On the Observation of Underground Water in the Matsunoyama Landslide Area

By Shinichi YAMAGUCHI, Yuji TAKADA and Atsuo TAKEUCHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 567–577.

Abstract

In order to presume the condition of underground water streaming in the Matsunoyama Landslide area (Matsunoyamatown, Higashi-Kubiki-gun, Niigata Prefecture), the underground water survey by the tracer method using NaCl and uranin has been carried out. As the result of this survey, it is presumed that the underground water streaming in the survey area was at least two lineage which distributed all of this area. It was clear that a throwing point and detected point of a tracer were connected with the same underground water streaming. But it was not known where the pass of the underground water which was streaming in and out in this area existed. And the information of this method is controlled by the number of the detected point in a landslide.

Therefore, the case of drainage works to prevent the mass moving, it is difficult to suggest the right position of the draining point by this method.

It was to find out how many underground water veins the underground water streaming in this area consisted of, and from what place those water veins streamed in and out.

Then, as one of the methods for getting this information, the underground water survey by the geothermal prospecting method was carried out. As the result, this knowledge was obtained from the systematic underground water veins in the Uradaguchi area, as follows:

1) There were two water veins coming from Usagiguchi area to the Uradaguchi area.

2) There were two water veins coming from the crushing zone which existed at the north-south direction at the west end of the Uradaguchi area.

3) There was one water vein coming from the upper stream direction of the Nakazawa-river which existed at the north end of the Uradaguchi area.

These underground water veins existed at the part of the Uradaguchi area, as follows:

The water veins of 1) existed at the south section of this area.

The water veins of 2) existed about the center section of this area.

The water veins of 3) existed at the north section of this area.

These wate veins existed in the large movement section of this area respectively.

In view of these facts, it was considered that this survey method was probably useful for the underground water vein survey. But this survey method has some problems to be resolved.

The Geophysical Prospecting for Landslide (Mainly on the Kebioka Landslide)

By Yuji TAKADA

Bulletin, Disaster Prevention Research Institute, Kyoto University,
Vol. 14, Part 2, February, 1965, pp. 15-27.

Abstract

The aim of this investigation is if there is a possibility of displacement in this landslide region: the outline of which is not known about it. In order to know the outline of the range of this landslide the electric resistance and the topographical survey were carried out in this region first.

From these reaults, the assumptions of moving and unmoving areas in this region are established, and according to these assumptions, measuring apparatuses were set up and several kinds of observations were carried out, in order to confirm if the assumptions are right or not, of the limitation of this electric survey. These results of surveys indicate that the electric resistance survey and the topographical survey are effective methods to assume the landslide condition and to plan other survey's schedules.

Practically always, observation on a slide, starts after the slide has already moved so that informations on a very initial stage of sliding is missing. Fortunately the author gained the information of the initial stage of sliding during the observation by tiltmeters and tensometers.

The surface displacement of this landslide is observed by tensometers. This displacement value is an expansion and contraction between two points, and not an absolute displacement value. At the middle of this landslide the tensometer records about 10^{-2} in expansion in a month. The first mass movement occurred in the lower part of the sliding area, and next in the middle and upper part. But during this movement the records of ground inclination measured by tiltmeters setting on the moving mass changed little, while the records of the inclination which were set on the unmovable mass assumed by the electrical survey showed the variation of 3′ as the ground surface inclination after one month when the tensometer on the moving mass showed the anomaly.

By internal strain meters the depths of the slide (shearing) surface are defined to be 40 m, of crushing andesite, and 70 m, in clay layer, at the top and middle of the sliding body respectively. These facts imply that the tiltmeter is not fit as a measuring aparatus for forecasting a landslide in this case; because the depth of the slide surface is rather deeper than other landslides.

On the Observation of the Internal Strain in the Landslide Area

By Yuji TAKADA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 579–587.

Abstract

In order to investigate the mechanism of a soil displacement and to decide the slide surfaces, observation has been carried out by the internal strain meters in the Toge Landslide area, Kashihara City, Osakafu, as from July 1963.

On the slide surface, it is found that there are two slide surfaces, one is at about 10 m depth which lies at tuff layer (which is called primary slide surface); the other in a more deep one which lies at brecciated and weathered andesite layer (which is called secondary slide surface), and which is almost the same as that of the slide surface of the Kamenose Landslide in 1933.

On the mechanism, it is shown that the pushing forces of the soil at the upper side of this landslide area causes the main factor of this soil displacement at each shallow slide zone and deep one. The variations of atmospheric conditions (especially rainfall) cause the soil displacement at the shallow slide zone but do not effect on deep slide zone directly. The velocities of the soil displacement at each slide zone from upper to lower side of the landslide area are about 1 cm/day at a shallow slide zone and 0.5 cm/day at the deep one respectively at the time when the soil displacement become maximum.

From Sept. to Nov. 1963, as one of the constructions to preserve, an earth-moving method at this landslide area had been done by the Kinki Construction Office. This author got the records of internal strain meter during this time, it showed that the strains at the shallow slide zone near the earth-moving region increased, and after, when the construction was over, those values were being decreased; and showed that the strains at the deep slide zone decreased after the earth-moving method. From these results the mechanics of these soil displacements of shallow zone and deep zone are different from each other and very complicated phenomenon.

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